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PROCEEDINGS

American Society
of
Sugar Cane Technologists

1974 MEETINGS

Volume 4 (New Series)

Florida and Louisiana Divisions

ASSET

May 1975

972

P R O C E E D I N G S
A M E R I C A N S O C I E T Y
O F
S U G A R C A N E T E C H N O L O G I S T S

Florida and Louisiana Divisions

VOLUME 4 (NEW SERIES)

May 1975

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FOREWORD

Although a procedure has been established with the intent of speeding up publication of the Proceedings, it is obvious that the method has not been effective. The primary reason for the delay in publication of the current volume is late submission of many of the papers to the editor. As pointed out in the Foreword to Volume 3, one of the problems encountered is the high number of papers presented orally at the 3 meetings each year for which manuscripts are not received by the editor. If an earlier deadline for printing of the current volume, January 11 for instance, had been adhered to, the number of missing papers would have approached 50%. The choice was made to delay printing in order to include several papers which were in the process of approval or still in preparation. Since in several cases the delay in submission of papers was not a fault of the author, I felt justified in holding up publication as long as seemed feasible. It is apparent that unless drastic changes can be made in the dates that manuscripts are received by the editor it will not be feasible to print the the Proceedings before May or June of the year following the meetings.

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PROGRAMS OF ASSCT MEETINGS FOR

1974

Program of Fourth Annual Joint Meeting
Orlando, Florida
July 25-26, 1974

July 25
Morning Session

Registration

Plenary Session

Welcome: Kermit Coulon, President, Louisiana Division

Welcome: John Boy, President, Florida Division

Address: Sugar Legislation - Horace D. Godfrey

Report: XV Congress, ISSCT - F. A. Graugnard, Jr., James Irvine, and Denver T. Loupe

Report: General Secretary-Treasurer - Denver T. Loupe

General Business

Afternoon Session

Joint Meeting of Agricultural and Manufacturing Sessions

Chairman: R. D. Breaux

Papers:

Inhibition of sugarcane yields by high water table during the dormant season -
Cade E. Carter and J. M. Floyd

Subsurface drainage for sugarcane: A field study - C. R. Camp and C. E. Carter

Spring planting of sugarcane in Louisiana - H. P. Fanguy and G. T. A. Benda

Sugar losses due to field mud - B. L. Legendre

Effects of freeze on sugarcane juice quality of several Louisiana varieties -
F. A. Martin, C. A. Richard, and M. J. Giamalva

Maturity studies of sugarcane varieties in Florida - Edwin R. Rice

Post-freeze deterioration of standing sugarcane as affected by variety and time -
J. D. Miller and G. J. Gascho

Evaluation of glysoffin on sugarcane maturity (Experiments on virgin land) -
John J. J. Chen and James C. P. Chen

Loss of sugars by leaves of sugarcane and related grasses - J. E. Irvine

July 26
Morning Session

Agricultural Section

Chairman: Larry Fowler

Papers:

Controlled photoperiodism in the basic sugarcane breeding program at Houma, Louisiana -
P. H. Dunkelmann and M. A. Blanchard

The genetic behavior of resistance to lodging in sugarcane: Methods of classification -
Howard P. Viator and M. T. Henderson

Comparison of two-stage selection schemes in sugarcane - N. I. James and J. D. Miller

Sensitivity of sugarcane varieties to gamma radiation and selection for mosaic-resistant mutants - R. D. Breaux

Bacterium associated with ratoon stunting disease - A. G. Gillaspie, Jr., and J. F. Worley

Field planting of sugarcane hot-water treated for sugarcane mosaic and ratoon stunting disease control - G. T. A. Benda

Greenhouse control of three seedpiece pathogens with thiophanate methyl - Shaw-ming Yang, and F. Seaberg

Mass screening of sugarcane selections for eye spot resistance - Jack L. Dean and J. D. Miller

Effect of number of cultivations on sugarcane yields in Louisiana - R. J. Matherne

A review of sugarcane borer controls in Louisiana - Stanley J. Viator

Manufacturing Section

Chairman: F. J. Blanchard

Papers:

Containerized cane handling - Jacob Giardina

Use of hydraulic motors as crusher and mill drives - T. R. Ray

The molasses-producing ions in Florida sugarcane juices - Ronald P. DeStefano

Polymers in cane juice clarification - James C. P. Chen

Vacuum pan performance - Guillermo Aleman

Control of grain size in refined sugar - Raul Esparza

The action of polymers in the fabrication of refined sugar - Jose A. Duenas

The use of instrumentation in the sugar industry - Pablo J. Fernandez.

Afternoon Session

Joint Meeting of Agricultural and Manufacturing Sections

Chairman: F. N. Bolton

Papers:

Sand land sugarcane - Gene Dodgen

Evaluation of sugarcane harvester components by use of high-speed photography - Joe E. Clayton

Mechanical harvesting at Glades County Sugar Growers Cooperative Association - Glenn Thomas

Green and burned sugarcane: A harvest comparison - J. R. Orsenigo

Aerial application results of paraquat to hand- and machine-cut sugarcane harvested by U. S. Sugar Corp. - J. Wayne Beardsley

The evaluation of chemical herbicides in Louisiana sugarcane - Ernest R. Stamper

A simple and rapid method to determine moisture and fiber in cane - Alfonso L. Fors

Sugarcane tops for cattle feed - F. M. Pate and S. W. Coleman

PROGRAM OF FIFTH ANNUAL MEETING OF THE FLORIDA DIVISION
Clewiston, Florida
October 24, 1974

Registration

Welcome

John B. Boy, President

Manufacturing Section

Chairman: Blas M. Rodriguez

Papers:

Use of Package Boilers in the Sugar Industry - P. K. Hall and G. A. Menendez

Computer Preparation of Daily and Weekly Technical Reports at Sugar Cane Growers
Cooperative of Florida - David Spooner and Rolando Estrada

Fireside Problems in Oil-Fired Package Boilers - G. A. Menendez and P. K. Hall

Utilization of New Approaches and Techniques in Improving Boiler Plant Operational
Efficiencies - John J. Opelka and Pedro R. Arellano

Agricultural Section

Chairman: Larry G. Fowler

Papers:

Development of a Mechanical Planter at Sugar Cane Growers Cooperative of Florida -
Larry G. Fowler and Fritz Stein, Jr.

Use of Computers at Sugar Cane Growers Cooperative of Florida - David F. Spooner

1974 ISSCT Meeting - South Africa - Stanley Hooks

A Short-Billet Continuous-Feed Sugarcane Planter - W. Stewart Boots

The Change in Regulations Concerning Off-Shore Workers - George Sorn

Napiergrass Eradication-A Cooperative Effort - Harry Samol

PROGRAM OF 1974 ANNUAL MEETING OF LOUISIANA DIVISION
Baton Rouge, Louisiana
February 7-8, 1974

February 7

Registration

Call to Order

Connie Melancon, President

Technical Session

Chairman: P. J. deGravelles, Jr.

Papers:

The Financing Outlook for Louisiana Sugarcane Producers - Vernon Wright

Core Sampling Study - Harold S. Birkett

Panel on Changes in Row Spacings in Louisiana Sugarcane: Rouby J. Matherne
Harold Willett
Stan Rodrigue
Charles Hodson

February 8

Technical Session

Chairman: F. J. Blanchard

Papers:

Processing Response of Cut-Chop Harvested Sugarcane - John J. Seip

Cane Quality in the Field - Billy J. Cochran

Panel on Use of Bagasse as Fuel: Victor Baillet
Bert Beyte

PAPERS PRESENTED AT FOURTH ANNUAL JOINT MEETING

Orlando, Florida

July 25-26, 1974

INHIBITION OF SUGARCANE YIELDS BY HIGH WATER TABLE DURING DORMANT SEASON ^{1/}

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ABSTRACT

Sugarcane variety CP 55-30 was grown in Baton Rouge, Louisiana, on Mhoon clay loam soil in 12 concrete bordered, 0.01-acre plots equipped for controlling the water table. Four plots each received constant water table treatments 12, 30, and 48 inches below the soil surface during the growing season in the plant crop (1970) and first ratoon (1971) and during both the growing and dormant seasons in second ratoon (1972) and third ratoon (1973). Cane yields among treatments were similar (approximately 45 and 35 tons/acre for 1970 and 1971, respectively) when water table treatments were imposed only during the growing season. Cane yields among treatments were significantly different in 1972 and 1973 when water table treatments were imposed during both dormant and growing seasons. Mean yield from 12- and 30-inch water-table treatments from second ratoon (1972) was 7.7 tons/acre less (17%) than that from the 48-inch water-table treatment. Third ratoon (1973) crop yields from the 12-inch and 30-inch water-table treatments were 17.7 tons/acre less (54%) and 7.1 tons/acre less (22%), respectively, than that from the 48-inch water-table treatment, while yield from the 12-inch water-table treatment was 10.6 tons/acre less (41%) than that from the 30-inch water-table treatment. Both stalk weight and plant population were adversely affected by high water tables. Subsurface drainage or other water management systems that may be used in Louisiana to alleviate high water tables that inhibit sugarcane yields should be designed to control the water table more than 30 inches below the soil surface, preferably 48 inches below the soil surface for the CP 55-30 sugarcane variety.

Sugarcane yields in Louisiana are relatively low compared to other cane producing states. Although the relatively short length of the growing season is partly responsible for this, other factors, such as irregular rainfall and high water tables, also contribute. For example, data in Table 1 show irregular monthly rainfall during 1970 to 1973.

Table 1. Monthly and annual rainfall, Baton Rouge, La., 1970-1973.

Year	Months												Total
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
	- - - - - Rainfall (inches) - - - - -												
1970	2.72	1.09	5.13	2.07	3.95	5.96	5.63	4.50	6.79	5.98	1.62	5.67	51.11
1971	1.31	4.59	5.32	0.74	2.96	2.97	7.04	2.59	7.23	1.73	2.84	10.93	50.25
1972	7.77	5.18	6.11	0.96	9.03	1.55	4.43	3.36	4.79	4.17	5.28	9.78	62.41
1973	3.55	2.77	11.77	10.44	4.36	3.01	4.48	5.85	11.11	2.54	7.97	7.90	75.75

Variation in monthly rainfall is typical in Louisiana's cane growing area and often results in an excessive supply of water for growing cane during some months and an inadequate supply during others. A more serious problem than erratic rainfall is high fluctuating water tables. Data, collected from piezometers in Mhoon and Commerce soils approximately 1 mile from the east bank of the Mississippi River near Baton Rouge, showed widely fluctuating water tables which frequently rose to within 1 foot of the soil surface (Fig. 1).

Water-table data collected recently from other soils commonly found in the sugarcane-producing area of Louisiana showed similar fluctuations. Cane farmers have attempted to offset this high water table problem by planting cane on high (12- to 18-inch) seedbeds so the seed pieces and stubble are as far as possible above the water table. This practice has merit but may not provide enough aerated soil for the cane seed pieces, stubble, and roots during high water tables. A practical solution to this problem is subsurface drainage. Experiments with small plots already have shown that controlling the water table well below the soil surface increased cane yields

^{1/}A contribution from the Southern Region, ARS, USDA, Baton Rouge, La., in cooperation with the Louisiana Agricultural Experiment Station.

over 50% and increased, by 2, the number of high yielding crops grown from a single planting (Carter and Floyd, 1972, 1973). Normally 3 annual crops are grown from one planting. These small-plot experiments also showed that the need for irrigation during droughts was reduced when water tables were controlled sufficiently to provide cane plants with greater rooting depths.

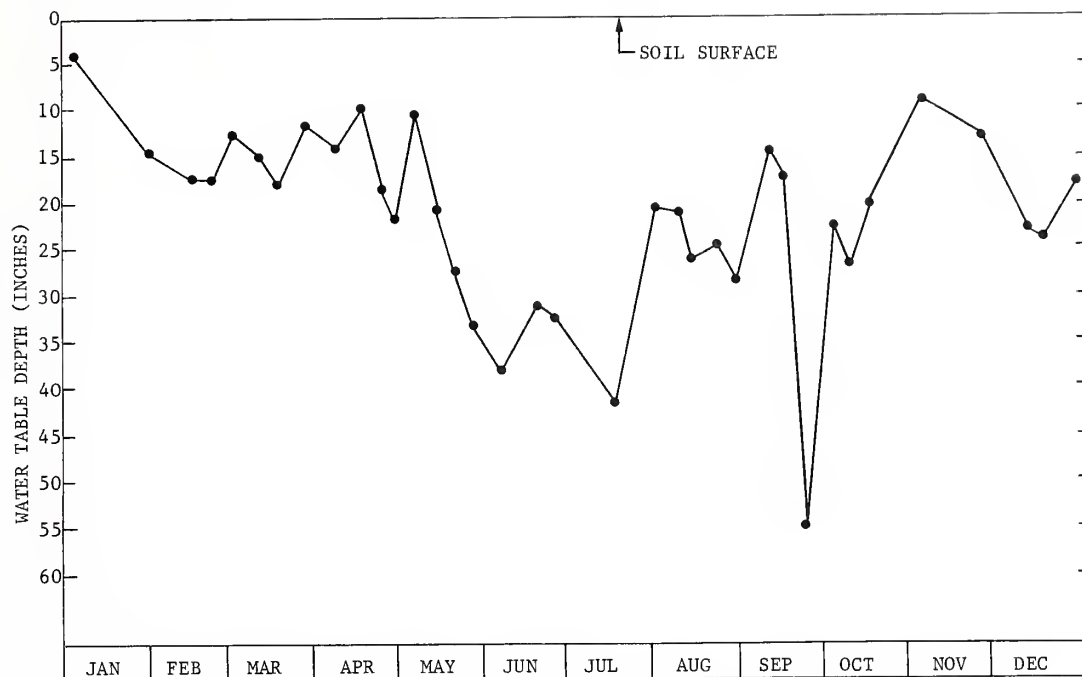


Fig. 1. Water table depth below soil surface of Mhoon silty clay loam near Baton Rouge, Louisiana, 1973.

Parameters, such as the maximum water-table height which cane plants can tolerate without inhibiting yields, are needed for designing efficient subsurface drainage systems. Other parameters concerned with depth and spacing of subsurface drains to control the water table are discussed in another paper of these Proceedings (Camp and Carter, 1974).

The purpose of this paper is to report the yield response of sugarcane to 3 constant water tables maintained a) during the growing season, and b) during both growing and dormant seasons. From these data, the maximum water-table height is given for use in designing subsurface drainage and other water table control systems in the field.

METHOD AND PROCEDURE

Concrete-bordered plots 0.01 acre in size were established on Mhoon clay loam soil at Baton Rouge, Louisiana, on the research farm of Louisiana State University. The concrete borders began 1 foot under the soil surface and continued downward 4.5 feet. Each plot was equipped with 2 tile drains connected by pipe to a sump which contained a water supply, valves, and a drain for maintaining the water level at any desired elevation from near the soil surface to 5 feet deep. The water elevation in each sump was adjusted to attain the desired water-table elevation in the plots.

Sugarcane, variety CP 55-30, was planted in the fall of 1969 in rows spaced 6 feet apart and on beds approximately 1 foot high. Constant water-table treatments 12, 30, and 48 in. below the soil surface were imposed on the 12 plots beginning in the spring of 1970. Each treatment was replicated 4 times. After 2 crops (plant crop in 1970 and first ratoon in 1971), the treatment was changed from maintaining the constant water tables only during the growing season (April to October) to maintaining them continuously (during both growing and dormant seasons). Then, 2 more crops (second ratoon in 1972 and third in 1973) were grown. During the dormant seasons of

the 1970 and 1971 cane crops the water table in all plots was approximately 3 feet below the soil surface.

Maintaining the 12-inch water table was difficult during the latter part of the growing season (September and October) each year. Even a 2-foot head in the water control sump was insufficient to force the water table in the concrete bordered plots upwards to the desired elevation. Sometimes the maximum water table height that could be obtained in the high water-table plots was 18 inches below the soil surface instead of the desired 12 inches. The water table in these plots could be maintained readily at 12 inches below the soil surface after the cane was harvested. Apparently, evapotranspiration (water evaporated from the soil and water transpired by the cane) exceeded the upward rate of water movement through the soil profile during the latter part of the cane growing season.

Conventional methods of cane culture were used, except for water-table control and hand weeding to control morning glory and johnsongrass. The cane was fertilized yearly with 200 lb of N (applied in split applications), 160 lb P₂O₅, and 160 lb K₂O per acre.

Cane was harvested by hand each year during early November. After burning the leaves and trash from the cane, the stalks were weighed for yields. Ten stalk samples were taken from each plot and analyzed for sucrose and brix. Stalks harvested from each plot were counted for plant population estimates.

RESULTS AND DISCUSSION

Sugarcane yield response was favorable to all treatments during the plant crop (1970) and first ratoon (1971) when high water tables were maintained only during the cane growing season (Table 2). The small differences in cane yield, sucrose percent, sugar yield, plant population, and stalk weight were not significant among treatments. Apparently the unsaturated volume of soil above the water table in each treatment was adequate for cane development and growth for this sugarcane variety.

Table 2. Cane and sugar yields, sucrose %, plant population, and stalk weight from constant water tables during growing season.

Year	Water table treatment (in.)	Yield			Plant population (no./acre)	Stalk weight (lb./stalk)
		Cane (net tons/acre)	Sugar (tons/acre)	Sucrose (%)		
1970	12	46.6a ^{1/}	3.29a	10.6a	34,472a	2.71a
	30	45.0a	2.80a	9.6a	32,334a	2.80a
	48	45.8a	2.62a	9.1a	33,194a	2.76a
1971	12	37.9a	2.73a	10.9a	41,500a	1.83a
	30	34.4a	2.50a	11.0a	42,139a	1.64a
	48	34.4a	2.29a	10.1a	41,389a	1.71a

^{1/} Treatment means followed by the same letter each year are not significantly different at the 5 percent level of probability.

Sugarcane yields were inhibited by high water tables during the dormang season (November to March). Mean yield from the 12-inch and 30-inch water-table treatments of second ratoon (1972) was 7.7 tons/acre (17%) less than that from the 48 inch water-table treatment (Table 3). Third ratoon (1973) crop yields from the 12-inch and 30-inch water-table treatments were 17.7 tons/acre (54%) less and 7.1 tons/acre (22%) less, respectively, than that from the 48-inch water-table treatments, while yield from the 12-inch water-table treatment was 10.6 tons/acre (41%) less than that from the 30-inch water-table treatment (Table 3).

Difference in yields from second ratoon is attributed to differences in stalk weight since plant population did not differ significantly among treatments. Both plant population and stalk weight contributed to yield differences in third ratoon (1973). Apparently high water table affected both. The number of stalks in the 12-inch water-table treatment from third ratoon (1973) was approximately 40% less than that in the other 2 treatments (Table 3). Stalk weights from the 12-inch and 30-inch water table treatments were approximately 20 percent less than those from the 48-inch water table treatment (Table 3).

Table 3. Cane and sugar yields, sucrose %, plant population, and stalk weights from constant water tables during growing and dormant seasons.

Year	Water table treatment (in.)	Yield			Plant population (no./acre)	Stalk weight (lb./stalk)
		Cane (net tons/acre)	Sugar (tons/acre)	Sucrose (%)		
1972	12	37.0a ^{1/}	2.76a	11.2ab	43,472a	1.69a
	30	39.2a	3.07a	11.7a	41,139a	1.91ab
	48	45.8b	3.24a	10.6b	44,486a	2.04b
1973	12	15.0a	1.48a	14.0a	24,861a	1.22a
	30	25.6b	2.31b	13.1a	39,861b	1.29a
	48	32.7c	2.93c	13.4a	41,889b	1.58b

^{1/}Treatment means followed by the same letter each year are not significantly different at the 5 percent level of probability.

Why plant population in the 12-inch water table treatment was adversely affected in the 1973 crop but not in the 1972 crop is unknown. Rainfall during the 2 dormant seasons, November to March, approximately the same, 33 inches. Perhaps population increase of soil pathogens or microorganisms was required before shoot development and survival in the stubble cane was affected. Additional research is needed to determine factors responsible.

Sucrose content of the cane juice did not differ significantly among treatments during any of the 4 crops, except second ratoon (1972) when sucrose from the 48-inch water-table treatment was significantly lower than that from the 12-inch water-table treatment. Relatively low sucrose in 1970, 1971, and 1972 is attributed partially to wind damage. Strong winds caused lodging and root damage to the cane each of these years and, apparently, sugars normally stored in the stalk were used by the plant in attempting to overcome this damage. High cane yield may also have affected sucrose. Other studies at this location have shown a tendency for sucrose to decrease as cane yields increase for variety CP 55-30 (Carter and Floyd, 1972).

Sugar yield per acre differed significantly among treatments only from third ratoon (1973). Higher cane yield from the 48-inch water table treatment in second ratoon (1972) was offset by significantly lower sucrose, consequently sugar yields were not significantly different that year.

Rainfall during the dormant season of the second and third ratoons was considerably more than during the dormant seasons of the plant crop and first ratoon (Table 1). This additional rainfall may have enhanced the findings of our experiment by causing extremely wet conditions, thus making more pronounced the difference between soil wetness in the high and low water table treatments.

Whether a high constant water table or a high fluctuating water table is more damaging to sugarcane during the dormant season is unknown. Factors, such as water-table height and the frequency and magnitude of water-table fluctuations, would influence this.

The relatively high cane yields obtained consistently from the 48-inch water-table treatment indicate that this water-table treatment was more favorable for cane production than the other 2 treatments. In designing subsurface drainage systems for alleviating the high water-table problem, drains should be placed in the soil at depths and spacings necessary to control the water table more than 30 inches below the soil surface, preferably near 48 inches.

The economics of subsurface drainage for sugarcane is promising. The increased cane yield expected from maintaining the water table well below the cane stubble during the dormant season can pay for subsurface drain installation from approximately 2 crops. The cost of a water-control (subsurface drainage) system depends mainly upon drain spacings since drain tubing per acre is a function of their spacing. If 130-foot spacings provide adequate water-table control, as indicated by Camp and Carter (1974), the cost per acre would be less than \$200, assuming the cost of the installed drain tubing is \$.50 per foot using gravity outlets. If pump outlets are required, the cost per acre would be slightly higher. A yield increase of 5 tons of cane per acre would more than pay for the drainage system in 2 years, assuming value of cane is \$30 per ton.

REFERENCES

1. Carter, Cade E., and J. M. Floyd. 1972. Effects of water table depths on sugarcane yields in Louisiana. Proc. ASSCT, Vol. 2: 5-7.
2. Carter, Cade E., and J. M. Floyd. 1973. Subsurface drainage and irrigation for sugarcane. Transactions ASAE, Vol. 16(2) 279, 280, 281, and 284.
3. Camp, C. R., and Cade E. Carter. 1974. Field evaluation of subsurface drainage for sugarcane in Louisiana. Proc., ASSCT, Vol. 4 (new series).

FIELD EVALUATION OF SUBSURFACE DRAINAGE FOR SUGARCANE IN LOUISIANA¹

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Baton Rouge, Louisiana

ABSTRACT

A field study is being conducted to determine the response of sugarcane to various subsurface drainage systems (treatments). Previous studies on bordered, 0.01-acre plots indicated that subsurface tile drains spaced 9 feet apart significantly increased cane yields and stand longevity. Plastic drainage tubing was installed in a 25-acre field plot of Mhoon silty clay loam (sicl) at various depths and horizontal spacings between drain lines to provide 5 treatments. Four treatments were: 3.5-foot depth and 20-foot spacing, 3.5-foot depth and 30-foot spacing, 4.5-foot depth and 40-foot spacing, and 4.5-foot depth and 80-foot spacing. The fifth treatment was a 4.5-foot depth and 40-foot spacing with a spyn nylon envelope surrounding the drain line. All other treatments were installed without an envelope material. Water table height and water removed from the soil by subsurface drainage were measured for all treatments. Soil water data indicated that all drainage treatments performed satisfactorily. Drain lines spaced as far as 120 feet apart may adequately drain Mhoon sicl for sugarcane.

INTRODUCTION

Most agricultural crops are adversely affected by prolonged periods of waterlogged conditions in the plant root zone. Crop growth and yield may be decreased on poorly drained soils as a result of reduced soil temperature in the early spring, poor aeration (gas exchange between the soil and atmosphere), poor soil structure, increased disease and parasite activity, and delayed farm machinery operations due to poor soil trafficability.

Controlled water tables alleviated prolonged periods of saturation in the root zone and increased sugarcane yields and stand longevity in Louisiana (Carter and Floyd, 1971, 1973). These results were obtained on small (0.01 acre), concrete-bordered plots with drain lines spaced 9 feet apart and with devices for controlling the water table height in the soil. Such a system would not be economically feasible for field use because of the very close drain line spacing and installation expense. A drainage system that provides soil conditions similar to those obtained with small plots, but using commercially available plastic tubing installed at much wider drain line spacings may be economically feasible. Several drainage-system designs that meet these requirements were installed in a field experiment to determine engineering design criteria for subsurface drainage systems, and the response (yield) of sugarcane to these designs. This paper describes the experimental facility and reports data and observations of the water table response to the various drainage system designs.

THEORETICAL CONSIDERATIONS

Subsurface drainage design criteria may be developed from empirical data collected on an existing system or from a theoretical analysis of a problem. Since empirical criteria are based on actual performance data and experience with a given installation, one must be careful in using these criteria for the design of systems in other areas.

Theoretical analysis applies proven physical laws to problems for which the limiting conditions can be defined mathematically and the theory can be tested through evaluation of existing drainage systems. The resulting mathematical expression will normally have several parameters. By assigning values to the parameters the theoretical analysis can be adapted to the local situation. The same expression can be used at other locations if the values for the location's parameters are known. Many different drainage theories have been developed for specific sets of boundary conditions, and some assumptions have been made to simplify the complex mathematical expression. When using these theories in designing drainage systems, one must be careful to match the field situation with the boundary conditions and assumptions used in development of the theory. The designer must also have either actual or estimated parameter values that reflect a particular drainage situation.

¹/Contribution of Agricultural Research Service, USDA in cooperation with the Louisiana Agricultural Experiment Station, Baton Rouge, Louisiana.

The derivation of several drainage theories was summarized by van Schilfgaarde (1970). Individual drainage theories were reported by Bouwer and van Schilfgaarde (1963), Dumm (1964), and Kirkham (1964). The SCS National Engineering Handbook (1971) gives guidance for the practical application of these theories. Before any of these theories can be applied to drainage for sugarcane, the parameters must be evaluated under field conditions.

The parameters vary with the equation, but can be classified generally according to the soil condition and crop they quantitatively describe. The unsaturated soil depth required for adequate root development and growth for a particular crop is one important factor. In equations developed for steady-state equilibrium, this is usually taken as the soil depth above the water table midway between the drain lines. In equations developed for transient conditions where the dynamic nature of the water table is considered, the rise and fall at the midpoint must be described in response to precipitation and evapotranspiration. To do this, one must determine the maximum time allowed from the water table to fall from some temporary high point in the root zone to a lower level near the bottom of the root zone. Other parameters include the drainage coefficient and the effective hydraulic conductivity. The drainage coefficient is the rate at which excess water must be removed to maintain the water table within design specifications. Hydraulic conductivity is the rate at which the soil will transmit water. Since hydraulic conductivity can vary considerably within a soil profile because of nonuniformity of the soil mass, an average or effective hydraulic conductivity for an entire field is often used for drainage design.

Various drain line depth-spacing combinations were calculated by using several drainage theories and estimated values for soil and crop parameters. The estimated parameter values were based on actual measurements, generalized ranges of values for a particular soil type, values used in other geographic areas, and personal experience. Drain line spacings computed by using the ellipse equation (SCS Engineering Design Handbook, 1971), a drainage coefficient of 0.015 in./hr, and a range of hydraulic conductivities and drain line depths are shown in Table 1.

Table 1. Drain line spacing predicted by typical design equation for several drain line depths and a range of hydraulic conductivity values.

Drain depth (ft)	Drain line spacings for hydraulic conductivity values in in./hr					
	0.05	0.1	0.2	0.3	0.5	1.0
	(ft)					
2.5	6	8	12	14	19	27
3.0	9	13	19	23	30	43
3.5	13	18	26	32	41	58
4.5	17	24	34	42	54	76

Since drain line spacing varies directly with the square root of the hydraulic conductivity in the ellipse equation, the spacing predicted for a given design situation can vary widely if the hydraulic conductivity variation is large. For example, if the drain line is at the .35-foot depth, the horizontal spacing between drain lines predicted by the equation varies from 18 to 58 feet as the hydraulic conductivity varies from 0.1 to 1 in./hr (see Table 1). This is not an unusually wide range in hydraulic conductivity, even within a single soil type. The drain line spacing generally increases with drain line depth and with increasing hydraulic conductivity (Table 1). The depth at which the drain line should be installed is influenced by crop and soil requirements, and, sometimes, by the equipment used to install the drainage system.

The ellipse equation may be used if: a) the groundwater is known to flow mostly in the horizontal direction, b) soil materials are underlain by a barrier at shallow depths, and c) porous trench backfill materials are used. Alluvial soils, which are very often stratified and contain relatively permeable silt layers that act as horizontal aquifers, can possibly satisfy the first condition. Therefore, the depth-spacing combinations calculated with the ellipse equation and presented in Table 1 were used in selecting the experimental designs to be evaluated.

EXPERIMENTAL DESIGN

The experimental site is on a Mhoon silty clay loam soil near Houma, Louisiana, where the natural water table is often near the soil surface. The 25-acre tract was precision graded to surface slopes of 0.15 to 0.2%. The site, bisected by a field ditch, was divided into 3 areas for precision grading. A large boundary ditch provided an adequate outlet for both surface and subsurface drains.

The drainage designs selected for evaluation on this site are listed in Table 2. We had planned to use a sand-gravel envelope on one each of the 40- and 80-foot drain line spacings. However, because unusually heavy precipitation resulted in unstable banks and very wet soils, the sand-gravel envelope was not used. Corrugated, polyethylene, agricultural drainage tubing was installed in July and August 1972, using a laser-controlled wheel-type trencher. The lateral drain lines were 4 inches in diameter, except in plot 5 where they were 2 inches in diameter.

Table 2. Subsurface drainage treatments installed for field evaluation on Mhoon silt soil at Houma, Louisiana.

Plot	Drain line depth (ft)	Drain line spacing (ft)	Envelope material
1	4.5	40	None
2	3.5	30	None
3	4.5	40	Spun Nylon
4	4.5	80	None
5	3.5	20	None
6	4.5	80	None

In each drainage design treatment (except plot 5) 4 parallel drain lines were connected to a 6-inch solid, corrugated polyethylene main line leading to a collection sump. In plot 5, three parallel drain lines were connected to a 4-inch perforated main line leading to the sump. Each collection sump (except plot 5) was 4 feet square and 10 feet deep. Sufficient sump storage to prevent excessive pump cycling was available since the drain line entered the sump 2 feet above the bottom. The collection sump for plot 5 was 2 feet square and 10 feet deep and also had 2 feet of storage below the drain line. Two submersible sump pumps were installed in each sump, one on the bottom and one at a height of 1.5 feet. The lower (primary) pump was controlled automatically by a float-actuated switch. The upper (secondary) pump operated when the water flow into the sump exceeded the pumping rate of the primary pump or if the primary pump failed. The capacity of each pump was approximately 30 gpm. The pumps discharged into a boundary ditch, which removed the water from the immediate area.

Two areas were used as checks. The first was adjacent to the drainage plots within the 25-acre tract; the other was about 1 mile away in the same soil type. The second area was selected as a precaution, in the event that the natural water table in the first area was influenced by the adjacent drainage treatments.

A recording rain gauge was installed to measure precipitation. The water level in each sump with time was determined with an FW-1 water stage recorder. From this record the number and frequency of pump operating cycles could be calculated. A positive displacement water flow meter in the discharge line of each pump indicated total discharge. Together, the total discharge and pump operating frequency could be used to calculate flow rates at critical times of operation and total flow for critical periods when no one was on site to collect data.

Perforated, 3/8-inch steel pipe was installed in the sugarcane rows to provide a cased well for measuring water-table depth. Wells were located along 2 lines perpendicular to the drain lines. One line was 200 feet from the west end of the field and the other was 200 feet from the east end of the field. The wells were used to determine the fluctuation of the water table due to precipitation and evapotranspiration. Wells were also installed in each of the control areas to monitor the natural water table. Tensiometers were installed in sugarcane rows adjacent to selected wells to determine the water content of the unsaturated soil above the water table.

The experimental area was planted to sugarcane, variety CP 52-68, in October 1972, under very difficult conditions. When the plant population did not reach an acceptable level in the next spring, the crop was plowed out and replanted in August 1973, to the same variety. A good stand developed for the 1974 season.

RESULTS AND DISCUSSIONS

The 40-foot and 80-foot drain spacings used in this experiment were expected to bracket the drain spacing needed to adequately drain Mhoon silty clay loam soil. Spacings greater than 80 feet, however, may provide adequate drainage, as data indicate excellent water table control from both 40- and 80-foot drain spacings. As an example, the water table response to subsurface drainage between 2 drains spaced 80 feet apart is shown in Fig. 1. The water table 4 and 11 days after a 4-in. rainfall was about 42 and 50 in., respectively, below the soil surface. Restricting the water table to these depths provides an unsaturated zone in the soil profile (above the water table) that is adequate for many crops. The 40-foot drain spacing provided similar water table control.

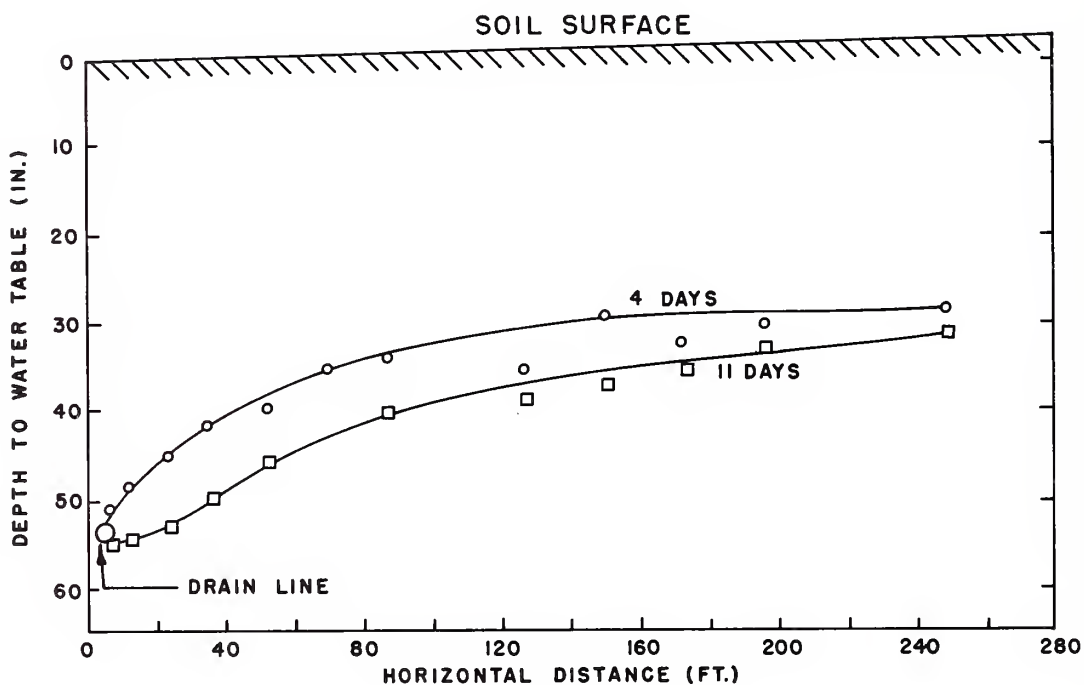


Fig. 1. Distances from soil surface to the water tables in drained and undrained plots 4 and 11 days after a 4-inch rain.

The excellent water table control on this soil is partly due to a silt layer in the soil profile at the same depth as the drain line. This silt layer, a characteristic of Mhoon silt soil, provides good horizontal movement of water.

The depth to the water table for the check plot is also shown in Fig. 1. The horizontal line for each time after rainfall is the mean of 10 observations from wells spaced at intervals of 50 to 85 ft across the undrained plot. The natural water table in the check (undrained) plot was about 26 in. above that in the subsurface-drained plots.

The extent of water-table control in an undrained field adjacent to a drain line, 4 and 11 days after a 4-in. rainfall, is shown in Fig. 2. The drain significantly affected the water table 60 to 100 ft away. This indicates that drains spaced 120 to 200 ft apart may provide adequate drainage. Since installation costs for subsurface drainage are based largely on the length of plastic tubing needed, the greater the spacing between drain lines required to satisfy the drainage requirement, the lower the cost per acre for installation. Additional data are needed, however, to verify the adequacy of 120- to 200-ft drain spacings.

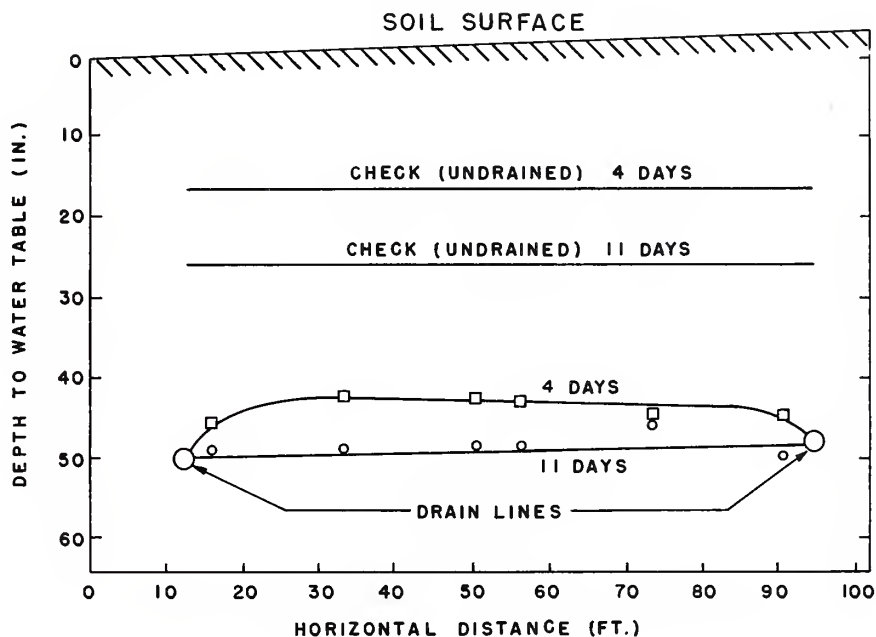


Fig. 2. Distances from the soil surface to the water table in a field adjacent to a drain line 4 and 11 days after a 4-inch rain.

One surprising observation has been the very short time between precipitation and accelerated flow from the drains for all drainage designs in this experiment. Whether water is actually flowing vertically through the soil profile or through some other tortuous pathway, possibly through interconnecting pockets of silty material, is unknown at this time.

The performance of the drain lines covered with a spun nylon envelope has not differed from that of the drain lines without an envelope. Sediment in each installation has been minimal. Further study and evaluation are needed, however, before envelope needs can be specified conclusively for drain lines in this and other soils of the lower Mississippi Valley.

With only the 2-year operation of this subsurface drainage installation, it is difficult to predict accurately the probably lifetime of a drainage system in this soil type and for the climatic conditions in the lower Mississippi Valley. Also, it is difficult to predict accurately the maintenance requirements for such a system. No unusual problems have been encountered. Iron ochre has been observed in small quantities and it is being monitored, but there are no indications that it will accumulate enough to present a serious problem.

Although some water table and drain line discharge data have been collected, only preliminary analysis has been completed. Sugarcane yield data will be collected in the fall of 1974, when the first crop is harvested. Therefore, this paper presents only a preliminary evaluation of the performance of the various drainage system designs.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the cooperation and assistance of the following: Southdown Land Co. for furnishing the plot site; Soil Conservation Service, USDA for assistance in site selection and survey; American Sugarcane League for their support; Anchor Sales Corp. for furnishing the trenching equipment and installing the plastic tubing; and Advanced Drainage Systems and Hancor, Inc. for furnishing the plastic drainage tubing. They also acknowledge the assistance of J. M. Floyd and R. A. Landry, Agricultural Research Technicians, USDA, ARS.

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SPRING PLANTING OF SUGARCANE IN LOUISIANA

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ABSTRACT

Although sugarcane is normally planted from August through December in Louisiana, usually some acreage is not planted because of prolonged rain or an early freeze. Experiments were conducted to evaluate spring planting of sugarcane in Louisiana. One compared CP 44-101 planted in October 1966 to CP 44-101 transplanted from the greenhouse in March 1967. Results showed that transplanted material yielded adequately at 18- and 30-inch intra-row spacings. In other experiments, spring transplants of stubble pieces or seedling sugarcane gave adequate stands. However, these methods required excessive labor, greenhouse, and irrigation facilities. In a second experiment, seedcane of the variety CP 65-357 was brought from Florida and planted in March and April 1973. In a comparison of different planting rates, adequate stands of sugarcane were obtained with rates of one and two stalks with no lap. The cane was short at harvest, and the March-planted cane outyielded that of April. The highest yielding treatment produced 17 tons per acre, which is considerably below yields obtained in fall planted sugarcane in Louisiana. The practicality of spring planting in Louisiana depends on availability and quality of seedcane, land preparation, weed control, weather restrictions, and the need for irrigation.

SUGAR LOSSES FROM FIELD MUD ^{1/}

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ABSTRACT

The effects of field mud in increments of 10, 20, and 30% by weight of cane on milling qualities such as fiber percent of cane, percent of normal juice extraction and sucrose, normal juice purity, and recoverable 96-pol sugar per gross and net ton of cane were investigated. Comparisons were made with results from trashfree controls. A regression analysis of the combined results, with corrections made for mud in extracted juices, indicated that each 10% increase in field mud caused a 0.5% increase in fiber percent of cane, a 9.1% decrease in the percent of normal juice extraction, a 0.7% decrease in percent of normal juice sucrose, a 0.5% decrease in normal juice purity, a 13.8-kg decrease in calculated 96-pol sugar per gross ton, and a 10.7-kg decrease in calculated 96-pol sugar per net ton of cane.

INTRODUCTION

Field mud has been proposed as the most detrimental type of trash in sugarcane harvested for sugar (3). Field mud has an approximate density of 1442 kg/m², 1.4 times the density of mature sugarcane and 3.5 times the density of sugarcane leaf trash. Consequently, a small quantity of field mud adds considerably to the percent of trash in cane.

Serious sugar losses result from cane trash (immature tops, green and dry leaves, and wet trash), especially if trash exceeds 10% of the harvested volume (7). However, little is known about the specific effects of mud on milling quality and sugar losses. Stewart (9) proposed that mill extraction figures are likely to be erroneous if juice weights include various quantities of mud. Also, mud affects boiling house efficiency by adding impurities to the extracted juice.

The present studies were undertaken to determine the effects of field mud on milling quality and sugar losses.

MATERIALS AND METHODS

Cleaned samples of sugarcane with known quantities of mud added and cleaned control samples without mud were milled (1). To insure a uniform distribution of cane and mud, cane was chopped into billets or pieces 15-25 cm long. Field mud was simulated with air-dried soil (Mhoon silt loam) mixed with water to a pasty consistency. Field mud was prepared and cane chopped just before milling.

Each sample was passed 4 times through a 3-roll (25- x 35-cm rolls) Squier mill with 30 tons of hydraulic pressure on the top roll. Maceration water (25% by weight of sample) was applied in three equal portions after each of the first 3 millings. Crusher juice was weighed, sampled, and discarded after the first milling. The mixture of juice and maceration water collected from the final 3 millings (mixed juice) was well mixed, weighed, and sampled. Samples of crusher and mixed juices were analyzed with a hydrometer for brix (soluble solids) and polarized for apparent sucrose, and appropriate calculations were made for apparent purity (ratio of sucrose to brix)(8). Juice samples to which mud had been added were first filtered to remove colloidal material. Bagasse weights were recorded and samples collected for fiber determinations (8).

Data on the brix and sucrose content of the crusher juice, the percent of normal juice extraction, and sucrose reduction factors were used to estimate yield of 96-pol sugar per ton of cane (6).

In 2 experiments conducted on Dec. 11 and 21, 1973, duplicate samples of the sugarcane cultivar CP 61-37 were harvested with 10, 20 and 30% mud and milled. Duplicate samples of cleaned cane were also milled.

^{1/}Research at this location is done in cooperation with the Louisiana Agricultural Experiment Station. This work was financed in part by a grant from the American Sugar Cane League.

Data were analyzed separately for each experiment and a combined analysis of variance was made for the 2 experiments. A regression analysis was calculated to measure the anticipated effect of field mud on fiber percent of cane, percent of normal juice extraction and sucrose, normal juice purity, and estimated yield of 96-pol sugar per gross and net ton of cane.

RESULTS

Mud used in these experiments averaged 71.8% dry matter and 28.2% moisture.

The combined regression analysis for the 2 experiments (Table 1) showed the expected relationships of field mud with fiber percent of cane, percent of normal juice extraction and sucrose, normal juice purity, and yield of 96° sugar per gross and net ton of cane. Fiber percent of cane showed a positive regression, and all other quality indicators showed negative regressions. The reduction in normal juice extraction and the loss of sugar per gross and net ton of cane after removal of the weight of mud in the expressed crusher and mixed juices were of particular interest.

Table 1. Regression analysis showing the effects of each 10% increase in field mud.

Parameter	Regression coefficients	
	Normal juice extraction not corrected for mud	Normal juice extraction corrected for mud
Fiber % cane	+ 0.5%	+ 0.5%
Normal juice extraction	- 0.4%	- 9.1%
Normal juice sucrose	- 0.7%	- 0.7%
Normal juice purity	- 0.5%	- 0.5%
Calculated 96 pol sugar per gross ton	- 5.0 kg	- 13.8 kg
per net ton	- 0.6 kg	- 10.7 kg

A combined analysis of variance for the 2 experiments with the raw data not corrected for weight of mud in extracted juices indicated a significant increase in both bagasse and fiber percent of cane (Table 2) as the level of mud increased. However, the increases were not significant at each successive 10% increase in the level of mud. The percent of normal juice extraction was significantly reduced only at the 30% level of field mud. The percent of normal juice sucrose was significantly reduced at each successive increase in the level of mud. Sucrose percent of cane was reduced by 13% as the level of mud increased to 30%. Normal juice purity was only slightly affected. Sugar losses per gross ton of cane were significant at each successive increase in the level of mud. However, no deleterious effect was noted on sugar recoveries per net ton of cane.

Table 2. Effect of field mud on milling quality and sugar recovery not corrected for weight of mud.

Mud (%)	Fiber % cane	Percent normal juice			Sugar (kg)	
		Extraction	Sucrose	Purity	Gross ton	Net ton
0	11.3 a ^{1/}	82.9 a	16.1 a	90.0 a	102.0 a	102.0 a
10	11.8 a	82.8 ab	15.3 b	89.6 a	95.9 b	102.0 a
20	12.4 b	82.4 ab	14.6 c	88.7 b	90.8 c	101.0 a
30	12.7 b	81.6 b	14.0 d	88.5 b	86.7 d	101.0 a

^{1/}Values in individual columns followed by same letter are not significantly different at the .05P.

About 20% of the mud was retained in the bagasse and accounted for the increase in both bagasse and fiber percent of cane (data not shown). Moisture percent of the bagasse increased from 50.7% for control to 53.7, 55.8, and 58.4% for samples with 10, 20, and 30% mud, respectively. About 80% of the mud was washed through the sugarcane mat into the crusher and mixed juices.

A combined analysis of variance for the 2 experiments was also calculated after correcting normal juice extraction for the weight of mud in the crusher and mixed juices (Table 3). Removing the weight of mud from these juices caused a significant reduction in the percent of normal juice extraction, especially when the mud weight exceeded 10%. Normal juice extraction for control samples averaged 82.9%. Samples with 30% mud had a normal juice extraction of 56.4%, a reduction of 26.5%.

Table 3. Effect of field mud on milling quality and sugar recovery corrected for weight of mud.

Mud (%)	Fiber % cane	Percent normal juice			Sugar (kg)	
		Extraction	Sucrose	Purity	Gross ton	Net ton
0	11.3 a ^{1/}	82.9 a	16.1 a	90.0 a	102.0 a	102.0 a
10	11.8 a	75.0 b	15.3 b	89.6 a	87.9 b	92.4 b
20	12.4 b	65.3 c	14.6 c	88.7 b	72.7 c	80.8 c
30	12.7 b	56.4 d	14.0 d	88.5 b	61.1 d	70.2 d

^{1/}Values in individual columns followed by same letter are not significantly different at the .05P.

Considering the reduction in the percent of normal juice extraction caused by field mud, sugar losses from the mud were quite serious (Table 3). Recalculation of the estimated yield of 96-pol sugar per gross and net ton of cane using adjusted normal juice extraction data (juice weights minus weight of mud) showed losses of 40.9 and 31.9 kg, respectively, in cane containing 30% field mud.

DISCUSSION

Previous studies demonstrated deleterious effects of cane trash (tops and leaves) on milling quality and sugar recovery, especially those in which the trash level exceeded 10% (7).

In this study, a 10% increase in field mud did not seem to be as deleterious as a 10% increase in cane trash. Preliminary calculations showed that the percent of normal juice extraction was not significantly reduced by field mud. A slight increase in bagasse and fiber percent of cane was caused by the 20% mud solids. The percent of normal juice sucrose was lowered by the addition of field mud, caused by the dilution effect of the moisture in the mud. Normal juice purity was slightly lower. The overall effect of field mud on sugar losses per net ton at first appeared to be negligible.

However, Stewart (9) noticed that juice weights that included various quantities of soil gave erroneous mill extraction figures and were reflected in the undetermined losses shown on the factory manufacturing report. In these studies, about 80% of the mud was washed into the juice, adding both weight and volume and inflating normal juice extraction figures. After the weight of mud was removed from the initial juice weights, the percent of normal juice extraction was considerably less than first determined. Actual loss of sugar per net ton of cane became apparent and was, in fact, significant at each subsequent 10% increase in the level of field mud.

Daubert (4) indicated that the amount of filter cake averages about 100 lb during dry weather and exceeds 200 lb in wet weather. Balch and Broeg (2) further stated that some Louisiana soils form colloidal suspensions that may floc under juice clarification and add considerable volume to the mud, with high sucrose losses in filter cake.

Field mud entering the factory also reduces overall plant efficiency and capacity by increasing the cost per ton of milled cane and causing more wear to knives, rolls, and conveyors (5). Field mud in bagasse reduces burning efficiency and results in high supplementary fuel rates.

This study verified that field mud caused a serious loss in estimated sugar recovery per ton of cane. The loss was due mainly to the effect of mud on percent of normal juice extraction and sucrose. Field mud appears to be more deleterious to sugar recoveries than is cane trash, as proposed by Cochran and Hadden (3).

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EFFECTS OF FREEZE ON JUICE QUALITY OF SEVERAL LOUISIANA SUGARCANE VARIETIES

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ABSTRACT

In continuing the effort to improve cold tolerance in Louisiana sugarcane varieties, the juice quality of 6 commercial and 3 unreleased sugarcane varieties was monitored from Dec. 13, 1973 through Jan. 3, 1974, at the St. Gabriel branch of the Louisiana Agricultural Experiment Station. The keeping quality of both cut cane and standing cane was evaluated for each variety. The data collected for each variety included acidity by titration, % sucrose by pol and % brix. As expected, varietal differences were observed in post-freeze changes in sucrose, purity, and acidity. Using minimum increase in acidity following freeze as criteria for cold tolerance, CP 65-357 and CP 68-361 showed levels of cold tolerance equal to or better than N Co 310, which is considered among the most cold tolerant varieties.

INTRODUCTION

Every year the Louisiana sugarcane industry faces the possibility of an early, severe freeze. The loss caused by an early freeze will vary with prefreeze environment, the severity of the freeze and post-freeze environment. Using several criteria, significant differences in cold tolerance and post-freeze deterioration rates have been demonstrated amongst Saccharum genotypes (2, 3, 4). These criteria included visual stalk damage, changes in juice quality determined by % sucrose, % purity, and juice titratable acidity, gum and/or dextran content. Demonstration of prefreeze varietal differences in these characteristics (2) emphasizes the necessity to quantitatively monitor these characteristics through the post-freeze period if those genotypes with the least post-freeze deterioration are to be identified.

MATERIALS AND METHODS

As part of the varietal selection program, the juice quality of 6 commercial and 3 experimental varieties was monitored in relation to post-freeze deterioration. Plant cane samples of the 9 clones were evaluated before and after freezing conditions which occurred during the 1973 harvest season at the St. Gabriel branch of the Louisiana Agricultural Experiment Station.

On December 13, 14, 17 and 20, prior to any freezes, each variety listed in Table 1 was sampled. Visual damage resulted from the freeze of Dec. 21. All samples before this date are referred to as prefreeze while samples 1 week and 2 weeks after this date are referred to as post-freeze.

On each sampling date, 3 replicates (4 stalks per replicate) were milled and the crusher juice analyzed for brix by hydrometer, sucrose by pol, and acidity by titration to Ph 8.3. Purity was calculated from sucrose and brix. Under the present system of cane payments, 2.5 is the maximum allowable acidity with no payment deduction (6). Therefore, statistical analyses were made using "t" test to determine if acidity of each variety by dates was greater than 2.5.

RESULTS AND DISCUSSION

Several criteria have been used as estimates of cold tolerance. Of the variables monitored in this experiment, acidity above 2.5 is presently the only one on which direct payment deductions of delivered cane are made. Realizing that acidity is probably only an indicator of the gum and dextran content which seem to be the real problem in the boiling house, we chose to define a cold tolerant variety as one whose post-freeze acidity did not significantly exceed 2.5. Therefore, we worked with the null hypothesis that a variety is cold tolerant, if its post-freeze acidity does not significantly increase above 2.5, using "t" test at 5% probability. If a variety's juice acidity increases significantly above 2.5, then we reject the null hypothesis and conclude the variety is not cold tolerant. The prefreeze and post-freeze acidity values for the 9 varieties tested can be seen in Table 1.

Table 1. Prefreeze and post-freeze acidity of 6 commercial and 3 experimental sugarcane varieties.

Variety	Prefreeze	1 wk post-freeze	2 wk post-freeze
NCo 310	1.70	3.37	2.79
CP 65-357	1.49	2.44	2.65
CP 68-361*	1.20	1.43	1.39
CP 52-68	1.17	2.48	4.59**
CP 61-37	1.30	3.07	5.98**
L 62-96	1.61	2.81	5.35**
CP 65-411*	1.44	2.40	3.99**
L 61-67*	1.23	3.07**	3.69**
L 65-69	1.88	3.69**	3.91**

*Ho: Experimental Varieties Acidity ($\bar{x}$) = 2.5 by titration to pH 8.3 with .1N NaOH.
i.e. variety is cold tolerant.

**reject Ho

NCo 310 is considered to be late maturing and the most cold tolerant of the commercial varieties grown in Louisiana (5). Probably because of extreme lodging and/or the degree of borer damage, the greatest amount of variation occurred within this variety. Throughout the sampling period the acidity level of NCo 310 did not significantly increase above 2.5.

CP 61-37 is considered to be a medium to late maturing variety with good cold tolerance (5). An increase in acidity was noted for the post-freeze period. Acidity significantly greater than 2.5 was detected 2 weeks after the freeze.

CP 52-68 is considered to have medium cold tolerance and is a medium maturing variety (5). Acidity levels were not significantly greater than the 2.5 level until the second week after the freeze.

L 62-96 is an early maturing, high sucrose variety as also is L 65-69 (5). The acidity level of L 62-96 increased significantly above the 2.5 level during the second week after the freeze. The acidity level of L 65-69 increased above the 2.5 level during the first week after the freeze. It is sometimes said that the cold tolerance of early maturing varieties is of little importance since they should be harvested before freezing temperatures. However, the average date for the first freeze in the center of the sugarcane belt is mid-November (1). These data emphasize the importance of getting early maturing varieties with little or no cold tolerance out of the field early.

CP 65-357 is the newest of the Louisiana commercial varieties. It is a high sucrose, early maturing variety with good cold tolerance (5). Throughout the sampling period, the acidity level did not significantly increase above the 2.5 level.

CP 68-361 is an unreleased variety which has reached the final stages of the selection program. There was no visual damage observed in this variety. The acidity level remained below 2.5 and gave no indication of any change in the prefreeze level. This variety shows evidence of cold tolerance and it may have some use as a potential breeding cane as well as possibly being released as a commercial variety.

The acidity level of CP 67-411 rose above 2.5 during the second week after the freeze. This variety shows a similar degree of post-freeze deterioration to that of CP 52-68.

L 61-67 is being reconsidered for release as a commercial variety and is an early maturing, high sucrose variety like L 62-96 and L 65-69. The acidity level of this variety rose significantly above 2.5 during the first week after the freeze.

The acidity of 6 varieties, CP 52-68, CP 61-37, L 62-96, CP 67-411, L 61-67 and L 65-69, significantly exceeded 2.5 by the 2-week post-freeze sampling date. We would then reject the null hypothesis for these varieties and conclude that they are not cold tolerant. These conclusions are in agreement with previous reports, except for CP 61-37 which was formerly

classified as being of good cold tolerance. Of these 6 varieties, there were 2 which had acidity levels exceeding 2.5 after the 1-week post-freeze sampling date, L 65-69 and L 61-67. The 3 remaining varieties, NCo 310, CP 65-357, and CP 68-361, did not have acidity values significantly greater than 2.5 and therefore from this data, appear to be cold tolerant.

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MATURITY STUDIES OF SUGARCANE VARIETIES IN FLORIDA

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ABSTRACT

Florida needs sugarcane varieties high in sucrose content throughout the long harvest season, which extends from late October to mid-April. A 2-year study of maturation patterns of 6 varieties, including the 3 most widely grown varieties in Florida, revealed important differences in the amounts of sucrose on the various sampling dates. For example, Cl 41-223, a late-maturing variety, showed an increase from 167.3 to 228.0 lb of sugar/t cane from November 1 to March 1 in the plant-cane crop. CP 63-306, CP 63-588, and L 61-49, all early-maturing varieties, averaged 193.2 lb sugar/t cane on November 1 in plant cane and surpassed all other varieties by significant amounts. All varieties averaged more sugar on all sampling dates in the first-stubble crop than in the plant-cane crop. Minimum temperatures did not severely damage the varieties during the 2 years.

INTRODUCTION

The highly successful production of sugarcane in Florida is partly aided by the long harvest season, which normally extends from late October to mid-April. Varieties are needed that mature at different times throughout this period, and a knowledge of the changes in juice quality of each variety during this period is extremely important to the grower and processor. A program of testing promising varieties for maturity date has been carried on for several years (4, 5). The purpose of this paper is to report the latest results of this program.

TEST PROCEDURES

An experiment designed to measure relative maturing qualities of 6 varieties was conducted on peat soil at Hatton Bros. farm during the 1971 and 1972 harvest seasons. Cl 41-223, CP 56-59, CP 63-306, CP 63-588, and L 61-49, all commercial varieties, and CP 66-1079, an experimental variety, were planted on November 30, 1970. The main plots of the experiment were 2-rows wide and 30-ft long, with 3 replications of each variety. Row width was 5 ft. Each plot was subdivided into five 6-ft plots for the 5 dates of sampling. That a different row was sampled in each of the two crops (plant cane and first stubble) eliminated bias associated with time of harvesting during the previous crop. The margins around the experiment were buffered to eliminate border effects and mechanical damage, but individual 3-row plots were not buffered. Standard methods of the cooperating farmer were used for planting, fertilizing, cultivating, and controlling of insects, rodents, and weeds. There were no drainage or irrigation problems, and the mature cane was not severely damaged by freezing temperatures during the 2 harvest seasons (2, 6).

Fifteen representative stalks were cut by hand from each 1-row plot on or near the first day of November, December, January, February, and March in each of the 2 harvest seasons.

Crusher juice was analyzed for brix and apparent sucrose. Indicated yields of sugar per ton of cane were calculated with the Winter-Carp formula as simplified by Arceneaux (1).

RESULTS AND DISCUSSION

CP 63-588 yielded an average of 189, 226, 222, 243, and 252 pounds of sugar/t cane, respectively, on the 5 plant-cane harvest dates and was not significantly surpassed by any other variety on any date (Table 1). In first stubble, CP 63-588 produced an average of 243 lb sugar/t cane on the 5 sampling dates. This variety was exceeded only by CP 63-306 in that category (Table 2). CP 63-588 is being rapidly expanded throughout the sugar area of Florida and presently ranks second in the number of acres planted (3).

L 61-49, a high-fiber, early-maturing variety, averaged 200 lb sugar/t cane on November 1 in the plant-cane harvest and was not surpassed by any other variety in this respect (Table 1). In first stubble, it produced 245 lb sugar/t cane in the average of the 5 sampling dates and was surpassed only by CP 63-306 in that category (Table 2). Although L 61-49 stubbles well, it is not widely used because of its unfavorable milling qualities.

Table 1. Indicated yields of 96° sugar, in pounds per ton of cane, in plant cane (1971-72) of 6 varieties in Florida.

Variety	Date of harvest					Mean
	Nov. 1	Dec. 1	Jan. 1	Feb. 1	Mar. 1	
CP 63-588	188.7a*	226.3a	222.3a	242.7a	251.9a	226.4A
L 61-49	199.6a	216.0a	215.0ab	240.4a	231.3ab	220.5AB
CP 63-306	191.3a	217.5a	209.4abc	225.3b	221.1bc	212.9BC
Cl 41-223	167.3b	200.3b	194.6bc	231.7ab	228.0ab	204.4C
CP 56-59	168.0b	189.2b	185.0c	194.1c	216.3bc	190.5D
CP 66-1079	164.9b	184.5b	184.5c	198.3c	196.8c	185.8D
Mean	180.0C	205.6B	201.8B	222.1A	224.2A	

*Means within columns followed by the same lowercase letter and means within rows or columns followed by the same uppercase letter do not differ significantly (5% level) according to Duncan's multiple-range test.

Table 2. Indicated yields of 96° sugar, in pounds per ton of cane, in first stubble (1972-73) of 6 varieties in Florida.

Variety	Date of harvest					Mean
	Nov. 1	Dec. 1	Jan. 1	Feb. 1	Mar. 1	
CP 63-306	232.0a*	259.4a	262.1a	261.1a	254.4a	253.9A
L 61-49	226.5ab	249.4ab	248.0a	254.6a	244.6a	244.6B
Cl 41-223	209.4bc	246.2ab	247.4a	262.2a	254.4a	243.9B
CP 63-588	220.6ab	236.4bc	248.8a	254.6a	252.6a	242.6B
CP 56-59	211.8bc	223.8bc	228.1b	229.5b	230.1b	224.7C
CP 66-1079	202.8c	219.2c	228.0b	225.2b	215.4c	218.1C
Mean	217.2C	239.1B	243.7AB	248.0A	241.9AB	

*Means within columns followed by the same lowercase letter and means within rows or columns followed by the same uppercase letter do not differ significantly (5% level) according to Duncan's multiple-range test.

CP 63-306 produced an average yield of 213 lb sugar/t cane in the plant-cane test and was significantly surpassed only by CP 63-588 in this respect (Table 1). In the first-stubble experiment, CP 63-306 averaged 254 lb sugar/t cane and was superior to all others in this category (Table 2). CP 63-306, released in 1971, is being expanded because of its early maturing and favorable milling qualities.

Cl 41-223, a late-maturing, low-fiber variety, increased from 167 lb sugar/t cane on November 1 to 232 lb on February 1 in the plant-cane test (Table 1). In first stubble, Cl 41-223 averaged 244 lb sugar/t cane and was significantly surpassed by only CP 63-306, in this respect (Table 2). The late-maturing quality of Cl 41-223 is responsible for the fact that it occupies more warm muck acreage than any other variety.

CP 56-59, a strong-stubbling, nonflowering variety, produced its highest yields of sugar per ton of cane on March 1 in both plant and first stubble. Although CP 56-59 does not produce yields of sugar equal to those of some other varieties, its strong stubbling characteristic has made it an important variety in Florida.

CP 66-1079, the only unreleased variety in the experiment, averaged only 186 and 218 lb sugar/t cane in plant cane and first stubble, respectively, in the study. These amounts were inferior to those of all other varieties in the test, except those of CP 56-59 (Table 1, 2). Although CP 66-1079 stubbles well, it does not produce acceptable yields of sugar per ton of cane and thus was not released to the industry for commercial production.

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POST-FREEZE DETERIORATION OF STANDING SUGARCANE
AS AFFECTED BY VARIETY AND TIME

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ABSTRACT

Eleven varieties of sugarcane grown in 38-l ash cans were frozen for about 9 hours in a controlled-temperature chamber. At 0, 2, 4, and 6 weeks, deterioration was estimated by determinations of brix, crusher juice sucrose, purity, raw juice pH, titratable acidity, and dextran. Sucrose and purity decreased for each successive sampling date. Brix and raw juice pH decreased at the 2- and 4-week sampling dates. Titratable acidity increased at each successive sampling date, whereas dextrans increased only at the 4- and 6-week sampling dates. Generally, varieties that maintained the highest sucrose content after freezing also had relatively high purity and raw juice pH and relatively low titratable acidity. Among the varieties tested, CP 57-526, Cl 61-205, CP 63-588, CP 69-1059, and CP 69-1061 had lower rates of deterioration than CP 63-306, CP 65-357, CP 68-1145, and CP 68-1154. Interactions between varieties and time after freezing were significant for all variables except brix. The highest correlation coefficients among the variables studied were between crusher-juice sucrose vs purity ($r = 0.975$) and crusher-juice sucrose vs crusher-juice pH ($r = 0.809$).

INTRODUCTION

Little work has been done in Florida on evaluating new sugarcane cultivars for keeping qualities after they have been damaged by freezing. Irvine (3) reported large increases in dextran content after severe freezes. Dextran has been associated also with lower quality by other research workers (1, 4, 6, 7). Titratable acidity has been used in the U.S. to indicate quality when frozen cane is milled. However, its use is questionable because Irvine (2) has reported levels of titratable acidity in unfrozen sugarcane that exceeded the lower level permissible in frozen cane. Gascho et al. (1) reported that in short-chopped cane, the pH of raw juice fairly well indicated deterioration. More research is needed to determine how various measures of juice quality affect sugar recovery in the factory.

The purpose of this study was three fold: (a) to determine if small-scale deterioration studies conducted in controlled environments yield data that are comparable to those obtained in the field, (b) to compare estimates of juice quality as affected by time, and (c) to evaluate the post-freeze deterioration in standing cane of 11 cultivars.

MATERIALS AND METHODS

Single-bud stalk segments of 11 cultivars were planted in the greenhouse in February 1973. In April 1973, 2 plants of each cultivar were transplanted into each of twelve 38-l ash cans. Plants were grown to maturity, with all stalks being tied erect.

The experiment was a 2-factor factorial (varieties x sampling dates) in a randomized complete-block design with 4 replications. A replication of a single cultivar consisted of 2 can cultures. Can cultures were transferred to small carts to be frozen. The freezing chamber was large enough to accommodate only half of the cans in this experiment.

Replications 1 and 2 were frozen on March 1, 1974, for 9 hours. The average air temperature at 75 cm above the soil surface was ≤ -3.8 C for 8 hours and -6.8 C for 3 hours. The average minimum soil temperature at 2.5 cm below the soil surface was $+0.3$ C. Replications 3 and 4 were frozen on March 2, 1974, for 9.5 hours. The temperature did not get as cold in replication 3 and 4, so the material was frozen for 0.5 hour more to try to damage the sugarcane stalks the same amount. The average air temperature was ≤ -3.2 C for 8.5 hours, with -5.2 C for 3.5 hours. The average minimum soil temperature at 2.5 cm below the soil surface was 0.2 C.

Immediately after removal from the freezing chamber, can cultures were transferred to a large room kept at 20 C for 16 hours. After can cultures were removed from the constant-temperature room, they were transferred to the crossing house where they were kept until the end of the experiment. During the first 4 weeks of this experiment, the minimum night temperature was kept at 20 C; after that the heat was turned off.

One stalk was selected at random from each can culture of each cultivar at each sampling date; the juice from the 2 stalks of each cultivar in each replication were composited for analysis. Stalks were topped at the first hard joint, and juice was expressed with a three-roller sample mill. Sampling dates studied were 0, 2, 4, and 6 weeks after freezing.

Brix was determined by hydrometer, or by hand refractometer when only a small quantity of juice was available. Crusher juice sucrose was obtained by determination of pol and conversion to apparent sucrose by the use of Schmitz' Table (10). Then purity was calculated as the ratio of sucrose to brix. The pH of raw crusher juice was determined with a glass electrode. To measure titratable acidity, 50 ml of crusher juice was titrated to pH 8.4 and expressed as milliliters of 0.1N NaOH/10 ml of crusher juice. Dextrans (as percentage of brix) were determined by a modified haze technique (6, 8, 9). Samples were read in a spectrophotometer at 720 microns. The instrument was zeroed for each sample with water instead of alcohol. This method eliminated interferences due to variations in juice color. All possible simple correlations were calculated among the six variables studied.

RESULTS AND DISCUSSION

The aboveground parts of sugarcane frozen in this experiment were completely killed, as evidenced by the lack of regrowth from terminal or lateral buds. Mean brix values for 11 cultivars at 4 sampling dates and overall means for cultivars and sampling dates are presented in Table 1.

Table 1. Mean brix values for 11 cultivars at 4 sampling dates and means across sampling dates and cultivars.

Cultivar	Time after freezing (weeks)				Cultivar mean
	0	2	4	6	
CP 57-526	19.8	18.8	18.1	17.9	18.6*cd
CP 61-205	21.7	20.2	18.8	18.6	19.8a
CP 63-306	19.0	18.8	19.2	18.5	18.9bcd
CP 63-588	20.5	19.8	20.1	20.5	20.2a
CP 65-357	19.8	19.4	19.0	19.7	19.5abcd
CP 66-1079	20.6	19.0	19.6	19.8	19.7ab
CP 68-1145	20.4	18.2	16.6	19.0	18.6d
CP 68-1154	20.8	20.1	19.1	18.3	19.6abc
CP 69-1052	19.5	17.2	15.6	15.6	17.0e
CP 69-1059	20.7	18.1	18.2	17.1	18.5d
CP 69-1061	22.4	20.2	18.8	19.3	20.2a
Time mean	20.5a	19.1b	18.5c	18.6bc	
CV	4.3	5.2	8.0	8.2	

*Means within rows or columns followed by the same letter do not differ significantly (5% level) according to Duncan's multiple range test.

The high brix values obtained in this experiment should not be expected under field conditions because the plants were grown in a 1:1 mixture of muck and sand, where water level was closely regulated. Several of the clones had high brix; only CP 57-526, CP 63-306, CP 65-357, and CP 69-1052 had a mean brix of less than 20.0 at the 0-week sampling date. Two cultivars, CP 63-588 and 69-1061, had mean brix values of 20.0 over the entire test period. Except for CP 63-306, brix values in this test decreased in each of the 2- and 4-week sampling dates. These data agree with those of Irvine and Davidson (5), who obtained a significant decrease in brix 6 days after the cane was severely frozen.

For each of the other measurements of quality, there was a significant interaction between cultivars and sampling dates. Therefore, generalizations across either time or cultivars could not be made. The clones of most interest in a variety-development program are those that maintain high juice quality after being frozen.

Mean apparent sucrose values of crusher juice decreased at each of the 4 sampling dates (Table 2). At the zero week, CP 69-1061 had the highest apparent sucrose of all the other

varieties in the test and kept a high ranking throughout the sampling period. Other clones that equaled CP 69-1061 in sucrose 6 weeks after being frozen were CP 57-526, C1 61-205, CP 63-588, and CP 69-1059. Clone CP 57-526 is of particular interest because at the 0-week it had one of the lowest sucrose values; yet 6 weeks after being frozen, it had one of the highest. Cultivars that had the highest losses of sucrose were CP 63-306, CP 65-357, CP 68-1145, and CP 68-1154. These cultivars had low sucrose values 4 weeks after being frozen.

Table 2. Mean crusher juice sucrose for 11 cultivars at 4 sampling dates.

Cultivars	Time after freezing (weeks)			
	0	2	4	6
CP 57-526	17.9*de	14.2ab	11.2abcd	9.3abc
C1 61-205	19.8b	16.6a	14.1a	10.7a
CP 63-306	17.4e	12.3b	7.6cde	1.6e
CP 63-588	18.5cd	14.8ab	10.4abcd	11.1a
CP 65-357	18.6cd	12.8b	7.4de	2.5e
CP 66-1079	18.5cd	13.0b	10.1abcd	6.5cd
CP 68-1145	18.2cde	11.8b	5.3e	2.7e
CP 68-1154	19.3bc	11.7b	9.8abcd	5.0de
CP 69-1052	18.1de	12.5b	9.1bcde	6.8bcd
CP 69-1059	18.6cd	14.3ab	13.1ab	8.6abc
CP 69-1061	20.9a	17.3a	12.1abc	10.2ab
Time mean	18.7A	13.8B	10.0C	6.8D
CV	3.6	14.3	27.5	32.9

*Means within a column followed by the same lowercase letter or means within a row followed by the same uppercase letter do not differ significantly (5% level) according to Duncan's multiple range test.

Mean purities decreased at each of the 4 sampling dates (Table 3).

Table 3. Mean purity for 11 cultivars at 4 sampling dates.

Cultivar	Time after freezing (weeks)			
	0	2	4	6
CP 57-526	90.5*abc	75.6abc	62.2abcd	52.2a
C1 61-205	91.5abc	81.8ab	75.5a	57.7a
CP 63-306	91.6abc	65.1cd	38.1dc	8.8f
CP 63-588	90.5abc	74.8abc	51.0bcde	54.9a
CP 65-357	94.0a	66.0cd	38.4de	13.0ef
CP 66-1079	90.0bc	68.1bcd	51.5bcde	32.4bcd
CP 68-1145	89.2c	64.5cd	31.2e	14.8def
CP 68-1154	92.8abc	57.9d	44.4cde	28.1cde
CP 69-1052	92.6abc	72.2abc	58.1abcd	43.2abc
CP 69-1059	90.1bc	78.7abc	72.0ab	50.2ab
CP 69-1061	93.4ab	85.2a	64.1abc	53.4a
Time mean	91.5A	71.8B	53.3C	37.1D
CV	2.3	11.8	27.6	32.9

*Means within a column followed by the same lowercase letter or means within a row followed by the same uppercase letter do not differ significantly (5% level) according to Duncan's multiple range test.

At the 0-week, before the cane was frozen, purities ranged from 89.2% for CP 68-1145 to 94.0% for CP 65-357. However, by the 2-week sampling date, purities had decreased considerably and ranged from 57.9% for CP 68-1154 to 85.2% for CP 69-1061. Four weeks after the cane was frozen, the outstanding varieties were CP 57-526, C1 61-205, CP 69-1052, CP 69-1059, and CP 69-1061. These varieties plus CP 63-588 were best also at the 6-week sampling date. After the

cane was frozen, purity dropped drastically at different intervals for different cultivars. In CP 66-1079 and CP 68-1154, purity dropped most within the first 2 weeks after freezing. However for CP 63-588 and CP 69-1061, the major drop in purity occurred between 2 and 4 weeks after freezing. CP 63-306, CP 65-357, and CP 68-1145 decreased almost 30% during each 2-week interval after freezing. The average decrease in purity was about 20% during the first 2-week interval after freezing. Irvine (5) found large decreases in purity after severe freezes in the field.

Another indicator of juice quality that can be simply obtained is crusher-juice pH (Table 4).

Table 4. Mean crusher juice pH for 11 cultivars at 4 sampling dates.

Cultivar	Time after freezing (weeks)			
	0	2	4	6
CP 57-526	5.25*bc	4.94a	4.49ab	4.56ab
Cl 61-205	5.35ab	4.70ab	4.66a	4.60a
CP 63-306	5.22bc	4.32b	4.35ab	4.28abc
CP 63-588	5.23bc	4.43b	4.22bc	4.48ab
CP 65-357	5.23bc	4.45b	3.98c	3.78d
CP 66-1079	5.15c	4.63ab	4.46ab	4.48ab
CP 68-1145	5.26bc	4.47b	4.38ab	4.42ab
CP 68-1154	5.30abc	4.44b	4.22bc	4.26bc
CP 69-1052	5.22bc	4.61ab	4.19bc	4.08c
CP 69-1059	5.29abc	4.70ab	4.57a	4.09c
CP 69-1061	5.42a	4.64ab	4.46ab	4.33abc
Time mean	5.26A	4.57B	4.36C	4.31C
CV	1.8	5.0	6.0	4.6

*Means within a column followed by the same lowercase letter or means within a row followed by the same uppercase letter do not differ significantly (5% level) according to Duncan's multiple range test.

Mean crusher-juice pH decreased at the 2- and 4-week sampling dates. In crusher juice from unfrozen cane, pH values ranged from 5.15 for CP 66-1079 to 5.42 for CP 69-1061. Two weeks after freezing, all of the pH values had dropped considerably and ranged from 4.32 for CP 63-306 to 4.94 for CP 57-526. Four weeks after being frozen, CP 63-588, CP 65-357, CP 68-1154, and CP 69-1052 had low crusher-juice pH values ranging from 3.98 to 4.22. There was little decrease in crusher-juice pH between 4 and 6 weeks after being frozen, except for cultivars CP 65-357, CP 69-1052, and CP 69-1059.

Titrateable acidity of the juice varied widely among varieties before freezing (Table 5).

Table 5. Mean titrateable acidity (milliliters of .1N NaOH/10 ml of crusher juice) for 11 cultivars at 4 sampling dates.

Cultivar	Time after freezing (weeks)			
	0	2	4	6
CP 57-526	3.00a*	3.57abc	5.30a	5.02abcd
Cl 61-205	2.46bc	2.85cd	3.49def	3.60cd
CP 63-306	2.15cd	3.48abcd	4.90ab	5.86ab
CP 63-588	1.78dc	3.08bcd	3.19def	3.36d
CP 65-357	1.96cde	2.99bcd	4.92ab	6.60a
CP 66-1079	3.12a	4.04ab	4.86ab	5.42abc
CP 68-1145	2.76ab	4.52a	4.71abc	6.26a
CP 68-1154	2.26cd	2.95bcd	4.16bcd	6.23
CP 69-1052	1.53e	2.34d	2.48f	3.52cd
CP 69-1059	2.24cd	2.50cd	2.86ef	5.10abcd
CP 69-1061	2.25cd	3.14bcd	3.76cde	4.08bcd
Time mean	2.32D	3.22C	4.06B	5.00A
CV	13.8	21.9	16.0	23.4

*Means within a column followed by the same lowercase letter or means within a row followed by the same uppercase letter do not differ significantly (5% level) according to Duncan's multiple range test.

Mean titratable acidity (milliliters of 0.1N NaOH/10 ml of crusher juice) increased at each sampling date for all clones, but increased less for CP 57-526, Cl 61-205, CP 63-588, CP 69-1052, CP 69-1059, and CP 69-1061 than for the other varieties. These results agree with data published by Irvine (2), who found differences in titratable acidity caused not only by cultivars, but by growing conditions and soil types. CP 65-357 had one of the lowest amounts of titratable acidity before freezing, but at the 6-week sampling time, it had the largest amount of titratable acidity present of all of the 11 varieties tested.

Before freezing only small amounts of dextran were present in these varieties (Table 6).

Table 6. Mean dextrans (as percentage of brix) for 11 cultivars at 4 sampling dates.

Cultivar	Time after freezing (weeks)			
	0	2	4	6
CP 57-526	0.10ab*	0.03b	0.13b	2.63bc
Cl 61-205	0.02c	0.01b	0.32b	3.66ab
CP 63-306	0.05bc	0.29a	2.15a	3.80a
CP 63-588	0.02c	0.05b	0.22b	2.64bc
CP 65-357	0.04bc	0.05b	0.45b	2.88abc
CP 66-1079	0.05bc	0.04b	0.70b	2.48cd
CP 68-1145	0.17a	0.06b	0.14b	1.59d
CP 68-1154	0.06bc	0.07b	0.51b	3.22abc
CP 69-1052	0.08bc	0.01b	0.66b	3.25abc
CP 69-1059	0.10ab	0.01b	0.04b	2.76bc
CP 69-1061	0.07bc	0.02b	0.19b	2.35cd
Time mean	0.07C	0.06C	0.50B	2.84A
CV	63.5	144.8	121.0	22.2

*Means within a column followed by the same lowercase letter or means within a row followed by the same uppercase letter do not differ significantly (5% level) according to Duncan's multiple range test.

All cultivars except CP 63-306 increased little in dextran content during the first 2 weeks after being frozen. Again at the 4-week sampling date, CP 63-306 was much higher in dextran than any of the other cultivars. The other varieties tested did not differ significantly. Six weeks after the cane was frozen, cultivars had enough dextran present to cause serious problems in sugar factories. Varieties having the lowest dextrans were CP 66-1079, CP 68-1145, and CP 69-1061. The variety CP 68-1145 is of interest because, although it did not have high dextran content, the other measures of juice quality showed rapid deterioration. Dextrans have been used by other workers as measures of deterioration in sugarcane after freezing or mechanical harvesting. In this test, dextrans (percentage of brix) did not change with time after freezing as rapidly as apparent sucrose, purity, crusher-juice pH, or titratable acidity.

All possible simple correlation coefficients among the 6 measures of juice quality are presented in Table 7. Correlation coefficients with brix were generally smaller than those with the other characters studied. Sucrose was highly correlated with purity and crusher-juice pH. Crusher-juice sucrose was negatively correlated with titratable acidity and dextrans. The inverse correlation between crusher-juice sucrose and dextran was the highest obtained for any character with dextran. Purity had the highest correlation with titratable acidity, followed closely by sucrose. Titratable acidity was the only character that was positively correlated with dextran formation.

It appears that small-scale controlled environment experiments can be used to evaluate post-freeze deterioration of sugarcane. The advantages of this type of experiment are the repeatability of freeze and post-freeze environmental conditions. Controlled-environment experiments will be used in the future to select sugarcane cultivars with superior post-freeze keeping qualities.

Table 7. Correlation coefficients among six measures of juice quality.

	Sucrose	Purity	pH	Titratable acidity	Dextran
Brix	0.498**	0.325**	0.422**	-0.155*	-0.293**
Sucrose		0.975**	0.809**	-0.760**	-0.626**
Purity			0.772**	-0.787**	-0.618**
pH				-0.689**	-0.441**
Titratable acidity					0.499**

*, ** Significant at the 0.05 and 0.01 levels, respectively.

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EVALUATION OF THE EFFECT OF GLYPHOSINE ON SUGARCANE MATURITY

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ABSTRACT

A field experiment was conducted within the 1973 crop to evaluate the feasibility of using Glyphosine (N, N-bis (phosphonomethyl) glycine) for enhancing the maturity of sugarcane grown in virgin land. The chemical used for this test has the grade name Polaris. Glyphosine at 2.5 and 3.5 lb per acre was applied to plant cane of L 60-25 and L 62-95. Two dates of application, September 18, and October 3, 1973, were compared. Sampling of cane and analyzing of juice were made weekly after each application. The sucrose content of the 2 varieties following the early treatment reached its peaks 41 days after treatment. No significant peak of sucrose content was observed in the late application. The early treatment of L 62-96 at 2.5 and 3.5 lb/acre and of L 60-25 at 3.5 lb/acre resulted in a moderate increase in standard ton of cane (TSC), with yields of 8.5, 6.8, and 5.8, respectively, as compared with the untreated check. The variety of L 62-96 appeared to respond to Glyphosine better than did L 60-25. Desiccation of the cane leaves, inhibition of the terminal growth and development of side shoots were observed. However, these characteristics were more common in the early-treated cane than in the late-treated one. Ratoon growth of the treated field was delayed in areas of poor drainage.

INTRODUCTION

This is a field-factory case study on the effects of a cane ripening chemical on cane yield (field aspect) as well as on the sugar recovery (factory aspect). Glyphosine is N, N-bis (phosphonomethyl) glycine.

Sugarcane planted in virgin land of high humic soil is expected to be very immature for grinding. If glyphosine is an effective sucrose enhancer, it should work particularly well with sugarcane that is not supposed to reach the normal maturity at the time of grinding. This was the reason why the test was programmed for virgin land of our Vacherie Division. It is a newly opened land of clay texture, with organic matter content of 2.08% and pH of 6.7. The cane was planted in October 1972 and received neither fertilizer nor pre-emergence herbicides. The chemical used for this test has the grade name Polaris.

MATERIALS AND METHODS

The experiment was of a factorial design and treatments were replicated 3 times. Two rates of Polaris and 2 dates of application were compared. The 2 rates of Polaris were 2.5 and 3.5 lb/A active ingredient in 7 gallons of water per acre and the 2 dates were September 18 and October 3, 1973. The varieties in the test were L 60-25 and L 62-96. The total tested area was 54.8 acres.

The first aerial application of Polaris (September 18, 1973) was 11 days behind the original schedule due to adverse weather conditions.

Combined cane-stalk samples were taken at weekly intervals from the day of treatment through harvest. Laboratory analyses and calculation for brix, sucrose, purity, acidity, invert, Clerget, pH and ash content were made. Average stalk weights were recorded.

The test fields of the first application were harvested mechanically on November 13, 57 days after the application of Polaris; whereas those of the second application were harvested on November 20, 49 days after treatment. Cane from each plot was hauled and weighed separately. Juice analyses for brix and sucrose were also made. Net and standard yields of cane were determined.

Observations on desiccation, lodging, and side-shooting were made. Periodical growth measurements and stalk counts at harvest were made. Cane stalk densities were also determined shortly before harvest.

A total of 19.95 inches of rainfall was recorded from September through November 1973. Although the rainfall recorded in October and November was normal, the excessive amount of water received in September (12.45 inches) saturated the poorly drained, treated fields throughout the entire test period.

The monthly average temperatures recorded at the Vacherie Office in September, October and November were 81, 76 and 69F, respectively, which were relatively warmer than the 58 year average recorded at the USDA Houma Station. (78 F in September, 70 F in October and 60 F in November.)

RESULTS AND DISCUSSION

Results from weekly sampling and juice analyses.

Statistical analyses of sucrose data from the weekly samples show that the responses of the treatments, including varieties, time of sampling, and rates used, to Polaris sprayed on September 18 were highly significant. Responses of the treatments (except rates used) to the chemical sprayed on October 3 were also significant. The differences in sucrose content between the 2 varieties and among the different times of sampling were particularly apparent in both applications. There were no interaction among varieties, time of sampling, and rate of the treatment for each application.

The data are presented in Table 1.

Table 1. Results from the weekly collected samples of Polaris test on cane maturity.

Variety	Polaris rate (lb/A)	Peak date sampled	Wt. @ Stalk	TCA	Sucrose	Purity	GDG (\$)	TSA
L 62-96	3.5	Oct. 29	3.01	33.87	12.61	77.32	+63.45	2.983
L 62-96	2.5	Oct. 29	3.07	34.55	12.20	76.70	+50.85	2.937
L 62-96	CK	Oct. 29	3.20	36.04	11.09	75.68	---	2.749
L 60-25	3.5	Oct. 29	2.38	29.37	11.90	77.68	+36.90	2.459
L 60-25	2.5	Oct. 29	2.25	27.77	11.56	76.00	---	2.221
L 60-25	CK	Oct. 29	2.44	30.11	11.16	76.33	---	2.323

Notes:

1. Date sampled was the day on which the sucrose contents of most samples reached their peaks.
2. Wt/stalk were the average weight per stalk from the samples collected weekly.
3. TCA (tons of cane per acre) was determined by multiplying the average stalk weight for three plots by the average stalk number per acre for the nine plots.
4. Sucrose and purity were obtained from the samples collected on October 29, calculated and converted to normal juice basis.
5. GDG (gross dollar gain) was calculated on the basis of \$22.50 per TSC.
6. TSA was tons of sugar per acre produced and was calculated from TSC on the basis that one TSC produces 166 lb of 96° sugar.

Changes in Clerget from the weekly collected samples show that the sucrose contents of the 2 varieties in the first application (Sept. 18) reached their peak on October 29, 41 days after the application of Polaris. It was normal for cane from the first application to reach the highest sucrose at about 6 weeks after treatment. The second application indicated a relatively high sucrose content in the October 22 samples, less than 3 weeks after treatment. The weather data show that the daily minimum temperatures remained around 70 F from mid-September until October 17 when the minimum temperature dropped to below 60 F and then remained between 50 and 60 F for about 2 weeks.

Based on the juice analyses of the October 29 samples of the first application, comparisons on the tons of standard cane (TSC) and the gross dollar gain (GDG) were computed per acre, respectively. Data for the late treated cane are not shown because it did not significantly respond to Polaris.

Results from harvests.

There were no significant differences in these data. Consequently, the results are not presented. The net yields (TCA) of Polaris-treated cane were generally lower, but the sucrose contents of treated cane were slightly higher, as compared with the untreated cane.

It is understood that the harvest was not done at the time when sucrose reached the peak (41 days), but rather at a time that it was declining (57 days).

If harvest had been done at the time of peak, the difference in TCA may have been smaller, and the difference in TSC and GDG may have been higher. (Shown in Table 1 and Table 2)

Table 2. Average length of stalk (inches) in 2 varieties of sugarcane following treatment with Polaris.

Dates of measurements	<u>Variety and Polaris treatment</u>					
	L 62-96			L 60-25		
	3.5 lb/A	2.5 lb/A	Check	3.5 lb/A	2.5 lb/A	Check
<u>Early Application (Sept. 18)</u>						
Sept. 18	86	86	87	78	79	79
Oct. 2	89	92	102	80	81	88
Oct. 24	91	100	119	81	82	95
Nov. 18	91	100	122	81	82	98
<u>Late Application (October 3)</u>						
Oct. 2	103	102	103	87	88	88
Oct. 24	108	114	120	94	97	106
Nov. 18	110	114	122	96	98	109

Other observations and measurements.

(a) Dessication - The leaves of both L 62-96 and L 60-25 showed spotty discoloration (mosaic-like) within a few days after treatment. Dessication of the cane leaves became clear about 2 weeks after the application of Polaris. It appeared that L 60-25 responded to the chemical faster and the degree of desiccation was much more severe compared to L 62-96. However, the L 60-25 in this test did not show more increase in TSC than L 62-96. The growing points of most stalks of the 2 varieties were also damaged (as though injured by freeze) shortly after treatment. Cane growth was apparently retarded.

(b) Lodging - No significant differences in the degree of lodging between the treated and untreated cane were observed. Cane was moderately lodged due to the stormy weather in early September before the Polaris treatment was made, however. Cane which was already lodged before the treatment received less amount of Polaris and showed less response, indicating that spray coverage was not as good as expected.

(c) Development of side shoots - Side shoots near the top of the stalk began to appear 3 to 4 weeks after treatment as a result of chemical damage to the apex. The top of the stalks of L 62-96 appeared to have more side shoots than L 60-25.

(d) Growth measurements - Polaris significantly reduced the growth of the early-treated cane of L 60-25 and L 62-96 and moderately retarded that of the late-treated plants. While L 60-25 responded to the 2 rates of Polaris with similar growth reduction, the 3.5 lb/A rate of Polaris reduced the height of L 62-96 much more than the 2.5 lb/A rate. Yet, the differences in the cane growth, between the treated and untreated cane in particular, were not reflected in the final yields, because all of the cane was topped off at about 78" above the ground. Comparisons of cane heights between the varieties and treatments are shown in Table 2.

(e) Density measurement - The average density of the stalks from the plots treated with Polaris was not significantly different from those of the untreated checks. Consequently, the data are not presented.

Effect of glyphosine on cane juice quality.

(a) Clerget sucrose - In order to measure the effect on content of actual sucrose, the Clerget sucrose has been used instead of polarization (Pol), commonly referred to as sucrose. The factory is interested in available sucrose for processing. By using certain chemicals to affect the composition of cane, the dextrose/levulose ratio may be physiologically altered and so the Pol values. This has been reported (1).

The effect of the Polaris treatments on Clerget sucrose is shown in Fig. 1 to 4.

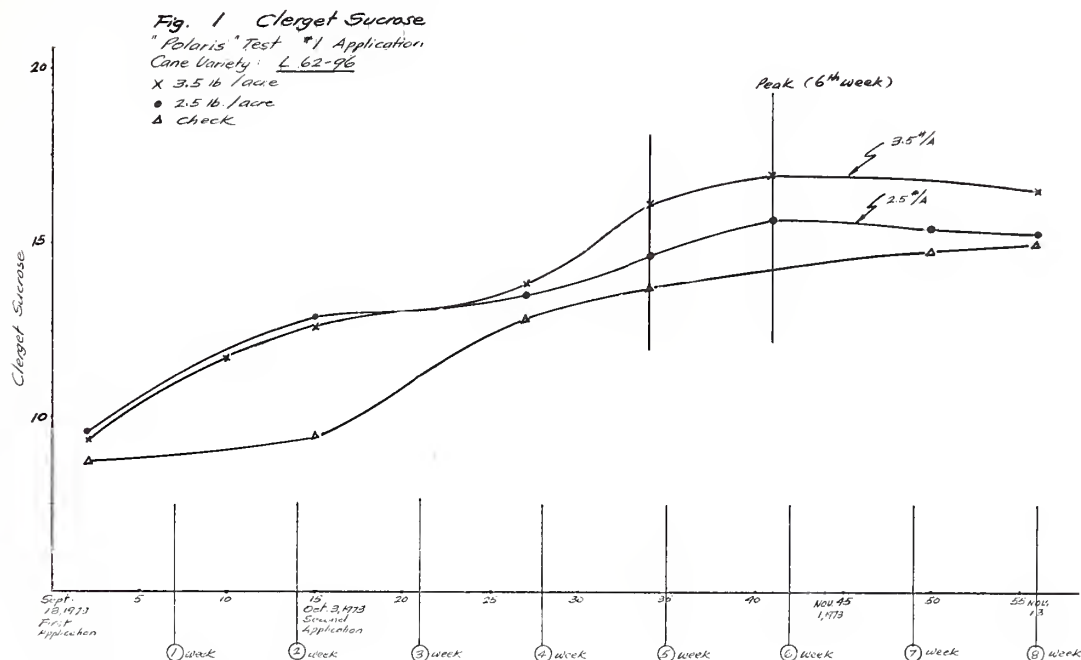


Fig. 1. Clerget sucrose

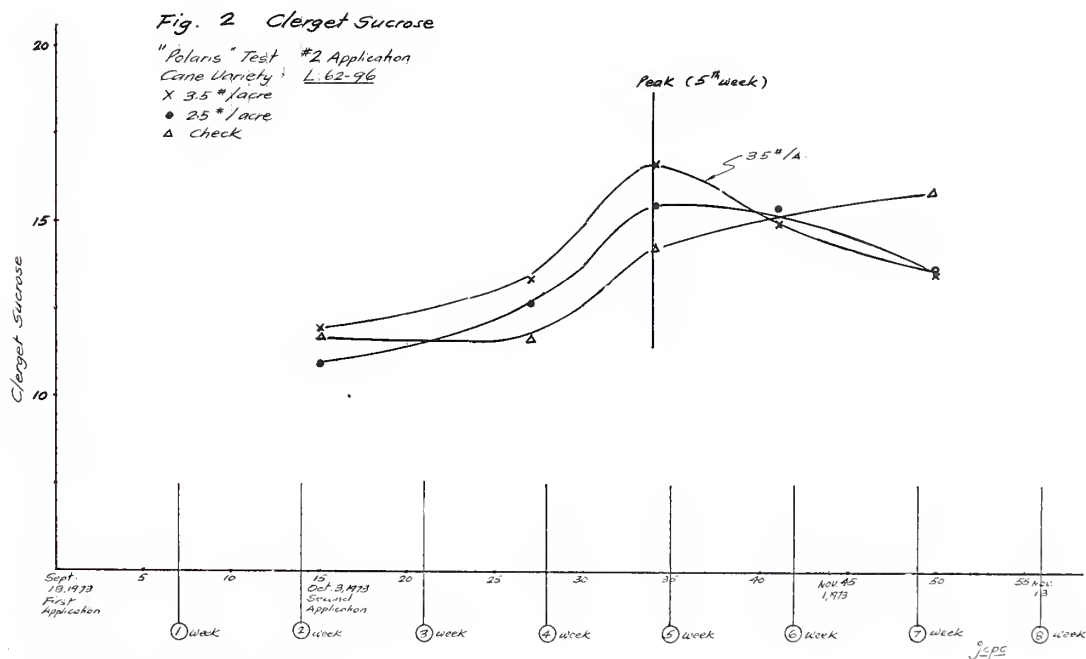


Fig. 2. Clerget sucrose

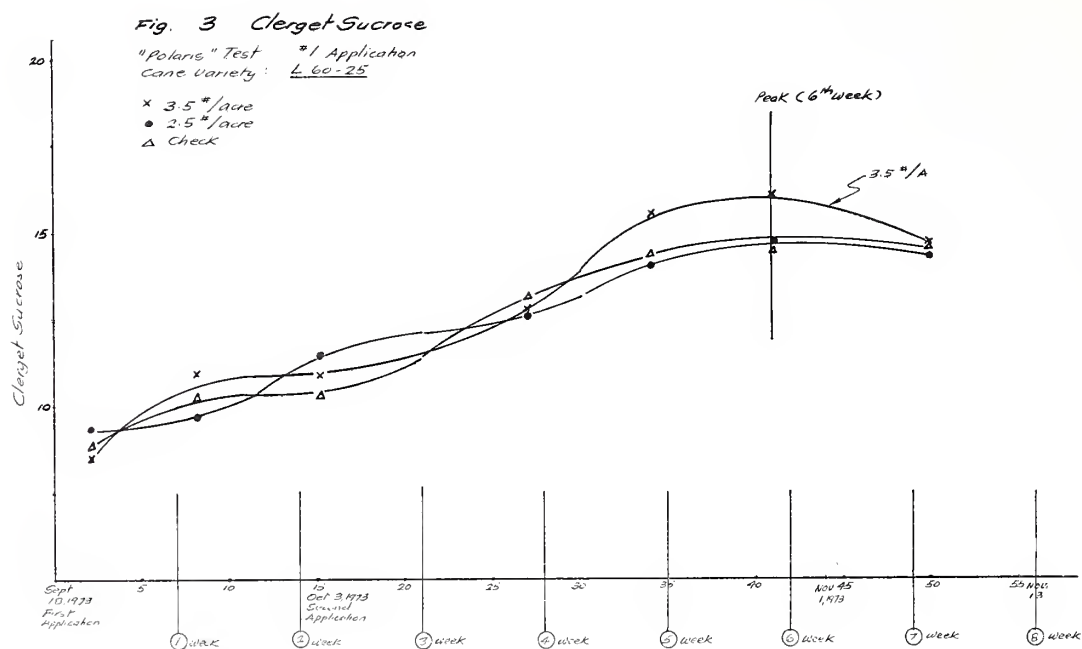


Fig. 3. Clerget sucrose

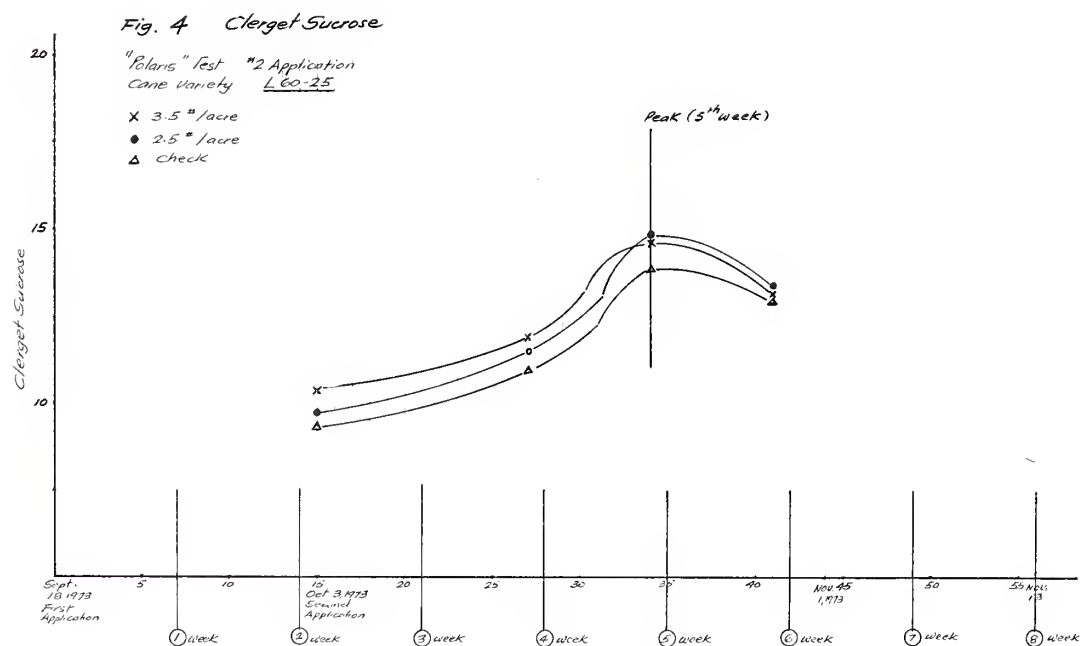


Fig. 4. Clerget sucrose

(b) Invert/Clerget

To promote maturity it is necessary to enhance the converting of monosaccharides (dextrose and levulose) into the di-saccharide (sucrose). So, a decrease in invert/sucrose should correspond to maturity, expressed in the increasing of sucrose.

The shapes of curves in Fig. 5 and Fig. 6 are almost identical to Fig. 1 and Fig. 3.

Fig. 5 Invert/Clerget
#1 Application, L 62-96

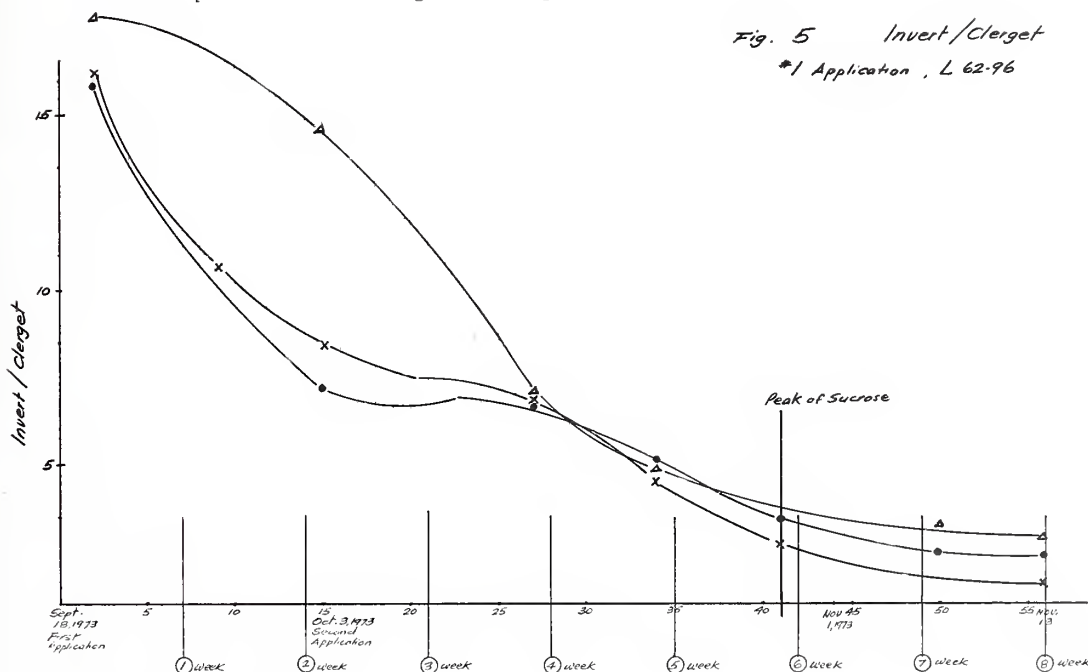


Fig. 5. Invert/Clerget

Fig. 6 Invert/Clerget
#1 Application, L 60-25

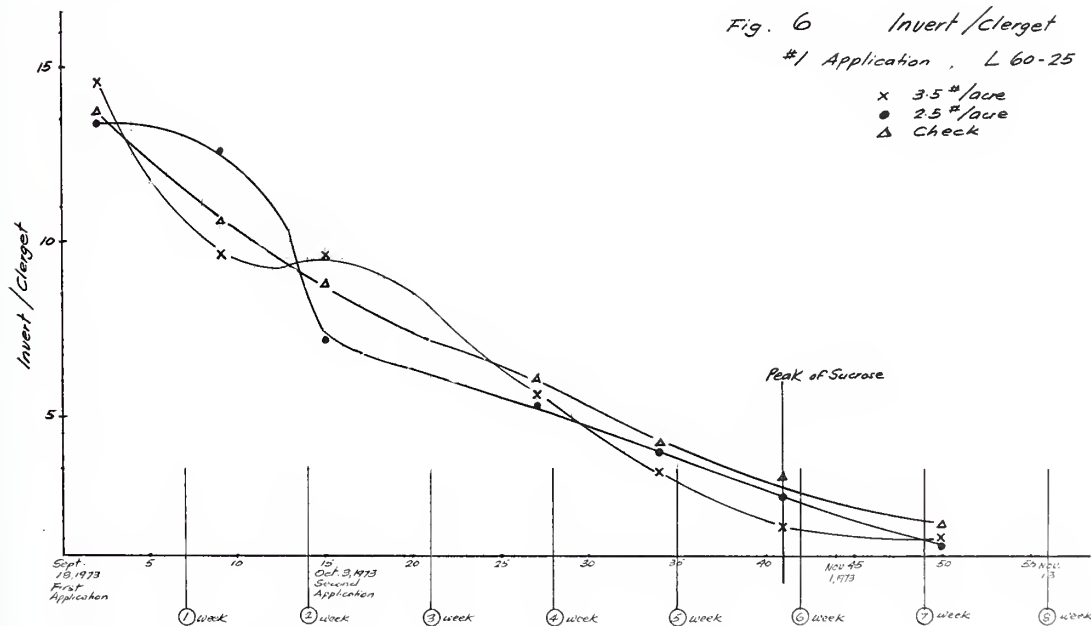


Fig. 6. Invert/Clerget

(c) Acidity

The acidity curves (Fig. 7) do not follow the same pattern as the change in sucrose. But because sucrose is higher in the treated cane, acidity is also higher than the check.

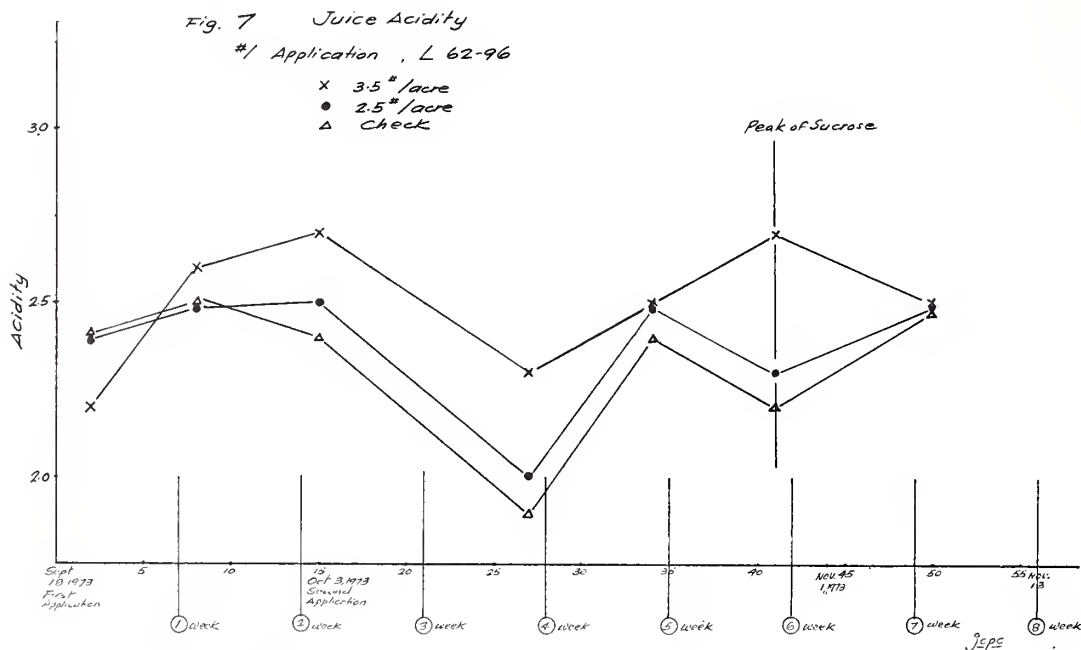


Fig. 7. Juice Acidity

(b) Ash (conductivity)

It would be more meaningful to use conductivity ash (Fig. 8) than the sulfated ash. The curves for conductivity ash follow a similar pattern to sucrose, increasing with time.

Although the difference between the treated and untreated is insignificant, the phenomenon shows that ash increases with maturity.

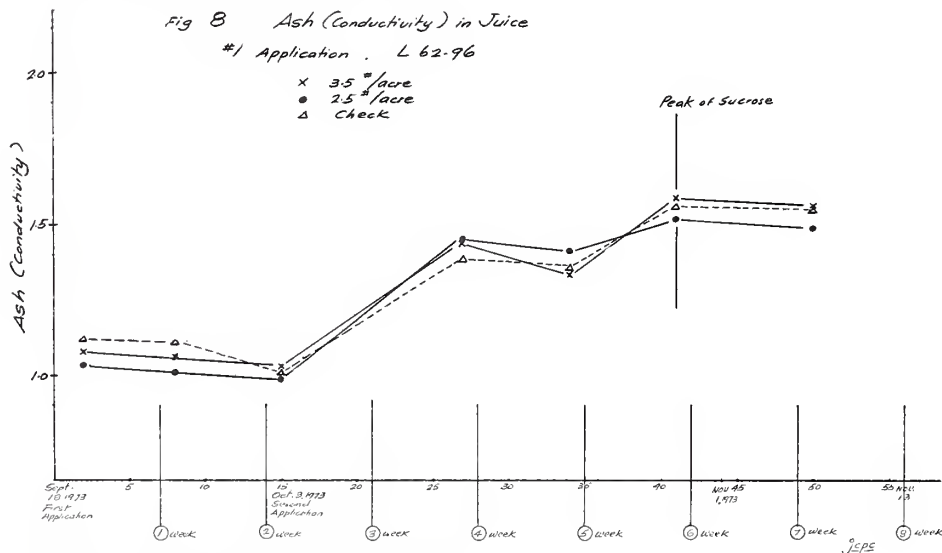


Fig. 8. Ash (conductivity) in juice

Effect of glyphosine to regrowth

The effect of glyphosine on stubble cane was one of the main concerns early this year when treated plots of the variety CP 52-68 on Oaklawn plantation in Feb. and Mar. showed no regrowth, in contrast to the check. However, other varieties such as L 62-96 and L 60-25 did not show any effect.

In early May, the authors made a field survey of the area in question, and by that time the regrowth of CP 52-68 on treated plots was comparable to untreated. The reason for the absence of regrowth in Feb. and Mar. was apparently a delaying effect of the chemicals.

In our test plots, a stand count on the treated and untreated plots was made in April 1974, showing very little difference, which is statistically insignificant.

IMPRESSIONS AND CONCLUSIONS

Different cane varieties do not respond equally to Polaris. L 62-96 responded much better than L 60-25. This confirms the observation of different varietal response in Hawaii (2).

The average increase in yield of sugar of 8.5% was similar to the 10% increase in Hawaii (3). Better results might be obtained from earlier treatment, possibly at the end of August or early September.

The drainage situation of the tested fields was generally poor; the fields were excessively wet from the day of treatment until the end of October. Tests on Polaris in Hawaii show that the results from irrigated areas have not been profitable (2, 3).

The aerial-spray coverage of Polaris was not uniform because the cane was moderately lodged before treatment and so received less than the desired amount of Polaris.

The natural build-up of sucrose in cane grown in clay and high humic soil is generally slow as compared to the cane grown in lighter, less humic and well drained soil. The effect of Polaris on enhancing sucrose of cane grown in the former soil could be less significant.

In addition to the unfavorable weather conditions during the growing season, which caused growth retardation, the excessive rainfall in September coupled with the continuous warm weather up to mid-October might also have slowed down the natural increase of sucrose. This could have reduced the effect of Polaris on cane maturity and sucrose increase.

Generally the regrowth of stubble cane is found to be no different between treated and untreated. Some varieties might be delayed in germination. But the varieties with good response and high sucrose yield did not show any difference.

This test has proven that with the help of a ripening chemical the cane may reach a normal maturity - with minimum sucrose content - for an early start of grinding. Not only the losses due to late freezes may be avoided, but also more standard tons of cane could be credited to the grower, and a higher sugar yield for the factory.

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LOSS OF SUGARS BY LEAVES OF SUGARCANE AND RELATED GRASSES

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ABSTRACT

Guttation water exuded from leaves of 'Rio' sorghum was dried, and analysis of the residue by gas-liquid chromatography showed the presence of dextrose, levulose, and sucrose. Dew was collected from a replicated planting of sugarcane varieties, and dried samples were found to contain these 3 sugars. No varietal differences were noted in the kinds of sugar lost. The quantity of sugar in the samples was higher in varieties with horizontal rather than vertical leaves; horizontal leaves had greater dew deposit. Pennisetum hybrids excreted sugars from localized areas on the leaf-sheath margin. The same 3 sugars were found; varietal differences in ratios of these sugars appeared to be related to the age of the exudate.

CONTAINERIZED CANE HANDLING

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ABSTRACT

A containerized cane handling system is utilized to transport cane from the field to the factory. The containers have a payload of 10 tons each. One container is placed on a trailer chassis that is drawn by a 90-100 H.P. tractor or a self-propelled hauling unit. When the container is full, it is transported to a transload station. The transload stations are located within one and .5 miles of the fields. At these stations the field containers are transloaded by a forklift unit to a flat bed trailer to be transported to the mill by a highway tractor. The tractor-trailer units haul two 10 ton containers each. At the mill the containers are unloaded directly onto the feeder table or stored with a forklift unit for night grinding.

In recent years we have seen a rapid introduction of combine harvesters in the industry. These harvesters harvest cane and chop it into billets 10" to 12" long. To handle this product, different methods of handling must be devised. One such method is containers.

By a container I mean virtually a 4-sided box of sufficient volume to hold the amount of cane desired. From experience we have found chopped cane has a density of approximately 21 lb/ft³ as compared to 16 lb/ft³ for long length, straight cane or 14 lb/ft³ for crooked recumbent cane. This high density makes mill storage in containers economically feasible.

Since the billet of cane is small and uniform, the size of the container is only limited to road regulations of width, height, length, weight, or road conditions if public hard surfaced roads are not used.

In a container system the containers are loaded in the field by the harvester, hauled to a transfer zone, transferred, and hauled to the mill. At the mill the containers are either dumped for direct grinding or put in storage.

Infield transportation of the containers can be done with various types of trailers designed to suit a specific field condition. This can range from a simple chassis with single or tandem axle to a sophisticated high flotation unit. This aspect is important because with the introduction of larger machinery into the fields, more consideration is being given to the effects of compaction.

The container system lends itself to reduced field compaction because infield units can be designed to operate only infield and not necessarily designed also for long road hauls.

Transferring the containers from the infield hauler to the road hauler is done by a standard fork lift. To accomplish this, permanent transfer areas of compacted fill material are set up at various points alongside the main haul roads. The infield units haul the containers to these areas where they are lifted off by a fork lift and put onto the truck, if one is available, or onto the ground for storage if trucks are not available. An empty container is loaded onto the hauler and it returns to the field. If desired, mill storage can be developed at these transfer areas. For example, the fields could work 10 or 12 hr per day and the road haul units 20 to 24 hr per day or any combination to suit a particular condition.

In a combine operation, the availability to transport determines the production of the harvester to a large degree. If transport is not available, the harvester cannot operate. Using containers, the infield transport operates independent of the road transport. The infield cycle of hauling to the transfer zone, unloading, and returning continues if road transport is available or not. Harvesting hours are not necessarily tied to the same working hours of the road transport. Transfer zones act as mill storage if harvesting works fewer hours per day than the road transport.

At the factory the containers can be dumped for direct grinding or put into storage. To get the containers off the truck, one of two methods is used. If a factory has sufficient capacity, a pusher and conveyor system can be used. In this system a hydraulic pusher mounted near the cane table pushes the containers 2 at a time onto a receiving conveyor. The receiving conveyor then feeds the dumper one box at a time.

As soon as the truck is unloaded, it then drives forward to receive 2 empty containers. These containers are loaded in exactly the same manner as the fulls are unloaded. The truck then returns to a transfer zone for reloading.

For factories of low grinding capacity, the mill-yard-handling facility is a dumper, one receiving conveyor and discharge conveyor, and 2 fork lifts. The fork lifts would do the dual job of feeding the receiving conveyor and developing storage. An economic feasibility study should be run to determine which system is best for a given factory.

For either method, at the same time direct feeding is going on, storage is also being developed. As trucks enter the mill yard and the waiting line starts to develop, trucks are diverted to the side where the containers are unloaded with a fork lift and put into storage. Empties are loaded with the fork lift, and the truck returns to a transfer zone.

With the container system, identification of suppliers is made easier. Container numbers can be recorded and identified from the time the container leaves the field to the time the cane is crushed. This simplifies crusher samples as a method of payment.

We have been working on the container system since 1967. In 1967 we supplied a self-propelled hauling unit hauling with 2 containers to a factory in Jamaica. The unit has been working ever since and at the time of this paper has clocked about 14,000 hr.

In 1968 we worked with Hawaiian Agronomics International (H.A.I.) and did the detailed design work for the container system used in the Amarah project in Iraq. We also did the basic design work for the container system Hawaiian Agronomics International used in Iran.

In 1973, we designed the system for the W. R. Cowley Sugar Factory in Texas, and supplied the complete mill yard handling facility.

The W. R. Cowley project was set up to grind 8,000 TCD with all the cane handled in containers. The cane for this project is spread throughout the Rio Grande Valley over an area 104 miles long and 25 miles wide. The average truck haul is 22 miles and the average infield haul is 2 miles.

The equipment to handle 8,000 TCD consists of 36 infield units, 4 fork lifts working in the field, 2 fork lifts at the mill, 300 containers, and 44 trucks. For the coming season, the intended capacity will be 9,600 TCD, and the fleet will be increased by 8 infield units, 2 spare fork lifts, and 6 trucks. The number of containers will remain the same.

The infield hauling units are simple trailers consisting of a chassis and tandem axle. The tandem axle is positioned rear of the center to give some weight transfer to the tractor for better traction. The trailers are equipped with 4 high flotation tires. Two cross beams are welded to the chassis to position the containers and hold it onto the trailer.

Four harvesting fronts are used to deliver the daily capacity. One fork lift for transferring is used with each harvesting front. This unit works at the transfer pad transferring the containers to and from the infield haulers and the trucks.

A simple air operated latching mechanism holds the container on the truck during transport.

An interesting point on these units is the favorable dead weight to load ratio. The containers average 4,500 lb each, the trailer 8,000 lb and carry a cane load of 44,000 lb, or 17,000 lb of machinery carries 44,000 lb of payload.

For the coming season, changes are being made where they were found necessary. These include:

- a) A scale is being incorporated in the sumper so each box can be weighed individually before and after it is dumped. It was necessary to do this because each truck brought in 2 containers and was weighed as one truck load. However, as the truck goes through the cycle, it does not leave with the same 2 containers. The containers differed in weight originally and will differ more so in the future as repairs are made. Even if each container weighed exactly the same initially, any cane left in the containers would give a false tare to the corresponding incoming load. The same holds true if harvesting is done in wet weather. If mud sticks to the container, its weight would change.
- b) The scale is also being added to the dumper to facilitate automation of weighing and sampling. A computer system will be set up to record the weight of cane in the container and timed such that when half of the cane is going through the first mill, a juice sample is taken. The grower's payment is then based on this information.

- c) When the conveyors were first supplied, we used conveyor chains to convey the containers to and from the dumper. We have found that rollers do a much better job of conveying containers, and we are now in the process of making the necessary changes.
- d) The speed of the dumper will be increased so it will have an average dumping capacity of 40 containers per hour and a maximum capacity of 45 per hour. The average cycle time at 40 per hour of a truck loading and unloading will then be 3 minutes.

USE OF HYDRAULIC MOTORS AS CRUSHER AND MILL DRIVES

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ABSTRACT

This paper will explore the use of hydraulic motors to drive 2-roll crushers and 3-roll mills. Results at Glenwood Cooperative, Napoleonville, Louisiana, where the world's first such hydraulic drive was employed in the 1973 crop, are given to demonstrate its advantages and disadvantages and to point out how it might be improved. Criteria are given to permit the design of such drives and to show where they might be successfully employed. Finally, experimental data taken at Glenwood on power consumption of 2-roll crushers are compared with standard formulas for calculating such power requirements.

THE MOLASSES-PRODUCING IONS IN FLORIDA SUGARCANE JUICES

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ABSTRACT

A number of inorganic nonsugars are present in sugarcane and are extracted along with the sucrose. Much of this material is not removed from the juice during processing and causes varying losses of sugar to molasses. Studies with plant cane show that the concentrations of calcium, potassium, and chloride ions in the juice of the commercially important Florida varieties may vary widely. The juice ion concentrations are also affected by growing conditions. The ramifications of these findings with respect to molasses exhaustibility and quality control are discussed and illustrated by recent results in the literature.

INTRODUCTION

Honig (7) lists a number of inorganic nonsugars which are present in sugarcane and are extracted along with the sucrose during processing. Table 1 lists the most abundant inorganic nonsugars, their usual concentrations in mixed juice, and the extent to which they are removed from the juice by normal processing. These figures are based on analyses performed in Java during the period 1930-40.

Table 1. The inorganic nonsugars in mixed juice (average of Java analyses 1930-40).

Nonsugar	Concentration Range (mg/L)	Extent of Removal
K ₂ O	800 - 1500	0
Na ₂ O	300 - 600	0
CaO	80 - 300	Increase during processing
MgO	100 - 250	Decreases at pH > 7.8
Fe ₂ O ₃	60 - 100	50 - 90%
Al ₂ O ₃	20 - 50	70 - 95%
C ₁ ⁻	100 - 300	0
SO ₃ ⁻	300 - 500	0
P ₂ O ₅	150 - 500	Removed to < 80 mg/L
SiO ₂	100 - 500	100%

The presence of these impurities in the juice causes sugar losses to molasses by at least 2 mechanisms: (a) the viscosity of the molasses is increased, making it harder to work efficiently, and (b) the solubility of sucrose in the molasses is increased (15). Exhaustibility problems have been observed by factory personnel to be especially evident in 2 situations: (a) during rainy weather when the water table is elevated, and (b) when cane grown on new land previously devoted to crops requiring high fertilizer levels is being ground. At least a partial explanation for this lies in the unusually high levels of inorganic salts made available to the cane under these conditions due to their high solubility in water in the first case and to their previous heavy application to the land in the second case.

Because of the obvious importance of these effects in processing, numerous workers have attempted to correlate the exhaustibility of molasses with the levels of various impurities present (3, 9, 13). One of the most recent attempts in this field is that of Gupta and coworkers in India (5). They were able to show that molasses purity was strongly influenced by the chloride ion content of the juice, with high levels of chloride causing increased losses of sugar.

To go one step further, Silina (14), working with beet molasses, showed that 25 different impurities possessed characteristic levels of molasses-producing ability. A melassigenic coefficient (m) expressing the number of pounds of sugar lost to molasses per pound of a particular nonsugar impurity present was assigned to each impurity examined. Three distinct classes of substances were so defined (Fig. 1): (a) very melassigenic substances ($m > 2.4$) like alkali carbonates and sodium and potassium chlorides and acetates; (b) moderately melassigenic substances ($m = 0.8-1.1$) like betaine, other sodium and potassium salts, amino acids, and lactic acid; and (c) slightly melassigenic substances ($m < 0.8$) like invert sugars, the alkaline decomposition products of invert sugars, all calcium salts, and sodium nitrate. Thus, the molasses-producing character of the juice's inorganic impurities depends not only on their concentrations but also on their exact chemical composition.

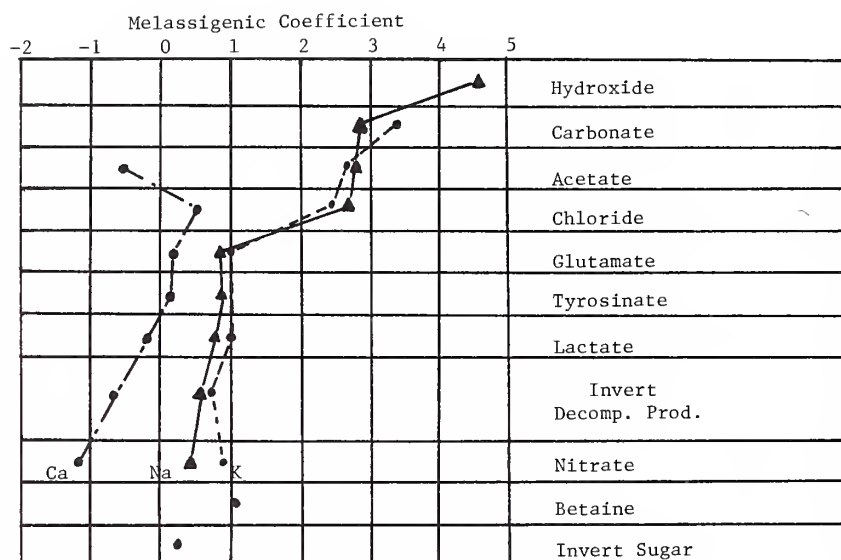


Fig. 1. Melassigenic coefficients of various nonsugars.

EXPERIMENTAL METHODS

Collection and Storage of Cane Juice Samples.

Cane varieties were sampled by choosing 8-10 healthy mature stalks, topping at the first green internode, and stripping away all trash. The juice was expressed through a small power-driven three-roller cane mill. After thorough mixing and screening to remove large debris, subsamples were collected in one-pint plastic jars with screw tops (Bel-Art Co.). The bottles were sealed by placing a piece of heavy plastic film under the lid and tightening down securely. The jars, with a small air space to allow for expansion, were then frozen at -10 to -20°C to prevent deterioration. Work in our laboratory has shown this procedure to be adequate for at least three months. Prior to analysis, the samples were thawed by heating at $30-35^{\circ}\text{C}$ for two hours in a thermostatted water bath and then filtered through ashless paper (Whatman #541 or equivalent). Mill juices were collected at the sample pipes in the quality control laboratory of the Clewiston Sugarhouse of United States Sugar Corporation and were stored without further preparation.

Analytical Procedures.

Dissolved solids were determined using a refractometer calibrated in brix units (Bausch and Lomb #33-45-71) and are corrected to 20°C (11). Sulfated ash was determined conductometrically using a multiplication factor of 167 to convert the readings of the conductance meter (Hach Chem. Co.) to percent ash. This factor was experimentally determined by comparing the conductance of a number of different juices with the sulfated ash determined by a standard method (12). Chloride was determined by diluting the filtered juice sample with 4-9 parts of distilled water and titrating with standard mercuric nitrate (Hach Chem. Co.) in the presence of a diphenyl-

carbazone indicator (Hach Chem. Co.) (6). Calcium (CaO) was determined in duplicate according to the method recommended by Payne (10). A weighed portion of filtered juice was acidified and clarified, then the calcium was precipitated as an oxalate salt which was titrated with potassium permanganate in strong acid. Potassium (K_2O) was also determined in duplicate as suggested by Payne (11). The potassium was precipitated as a salt with sodium cobaltinitrite ($\text{Na}_3\text{Co}(\text{NO}_2)_6$), washed, and determined gravimetrically.

RESULTS AND DISCUSSION

During the 1973-74 season, data on some of the more important inorganic impurities present in the juice of some commercially important Florida varieties were gathered. The ions examined were calcium, chloride, and potassium. In addition, the effect of processing on the levels of these inorganic impurities in the juice was investigated (Table 2).

Table 2. The effect of processing on the levels of potassium, calcium, and chloride in Florida cane juice.

Juice	Nonsugar concentration (ppm)		Chloride (Cl)
	Potassium (K_2O)	Calcium (CaO)	
Crusher	2263	599	912
Mixed	1491	460	742
Clarified	1607	516	799

In agreement with the early studies on juice in Java, it was found that normal processing did not effectively remove any of the impurities investigated. The apparent discrepancy between values for crusher and mixed juices is the result of dilution. These figures are the mean values for several juice samples taken at random from the Clewiston sugarhouse of United States Sugar Corporation during normal operation. The juice contained significantly higher levels of all 3 impurities than did the juice in Java discussed above (Table 1), and a number of factors such as fertilizer practices, soil composition, and varietal influences undoubtedly enter into this difference. Particularly interesting are the figures for calcium (CaO); the very high concentrations of calcium in Florida juices are a major cause of the heavy scaling so common in factory vessels (2). This problem has also been observed to be aggravated during rainy weather and when processing cane from new land which has been heavily fertilized in the past.

The varietal influence on levels of inorganic impurities present in the juice was investigated using some important Florida varieties (Table 3). All samples were mature plant cane (18-19 months old) grown on sandy soil (composition: 11% organic matter, 9% non-silicate minerals, and 80% sand) (1). It is obvious that these varieties differ markedly in the levels of the impurities present in the juice. Also worthy of note is the fact that the levels of the 3 impurities in a given juice appear to be independent of each other. For instance, while Cl 41-223 juice contained over twice as much potassium as Cl 61-5 juice, the levels of chloride and calcium were nearly identical. Expressing the levels of the impurities on the basis of juice solids more accurately reflects the impact of these differences upon processing (Fig. 2), since boiling house operations are based on brix. Quite significant are the differences in the levels of the very melassigenic chloride and potassium ions. It was noted, however, that all of the juices examined contained levels of ions which were far below those found with factory juices (Table 2), thus indicating the importance of additional factors besides varietal influences.

Another obvious factor to be considered was soil composition. To this end, 7 of the same sugarcane varieties used in the previous study were sampled from a nearby location having muck soil (composition: 86% organic matter and 14% non-silicate minerals (1)). Age of cane, methods of cultivation and time of application of fertilizers were identical in both studies. While the fertilizers applied were not identical mixtures due to the varying soil composition, they did contain identical amounts of those ions being investigated. As shown in Table 4, the mean levels of all three ions were higher in the juice of the canes grown on muck soil. Presentation of these data in slightly different ways yields additional information (4). Fig. 3 shows the data expressed on the basis of dissolved solids (by refractometer) and indicates how the impurities present affect the processing quality of the juice. Fig. 4 shows the same data expressed on the basis of ash and indicates the selective action of the plant roots in accepting or rejecting the minerals present in the soil as determined by varietal influences.

Table 3. Concentrations of potassium, calcium, and chloride in the juice of 12 Florida cane varieties grown on sandy soil.

Variety	Potassium (K ₂ O)		Calcium (CaO)		Chloride (Cl)	
	PPM in juice	Lb/T solids	PPM in juice	Lb/T solids	PPM in juice	Lb/T solids
Cl 41-223	1229	12.4	311	3.2	490	5.0
Cl 54-312	254	2.2	217	2.0	345	3.2
Cl 54-336	155	1.4	284	2.6	295	2.6
Cl 54-378	182	1.6	313	2.6	148	1.2
Cl 54-405	1301	12.2	312	3.0	650	6.2
CP 56-63	1779	17.6	339	3.4	783	7.8
CP 57-603	944	9.6	357	3.6	884	9.0
Cl 59-1332	756	6.2	431	3.6	268	2.2
Cl 61-5	581	5.4	305	2.8	415	3.8
Cl 61-205	778	7.0	190	1.6	455	4.0
CP 62-374	940	8.2	672	5.8	478	4.2
CP 63-588	270	2.6	639	5.2	393	3.8
Mean	835		355		467	

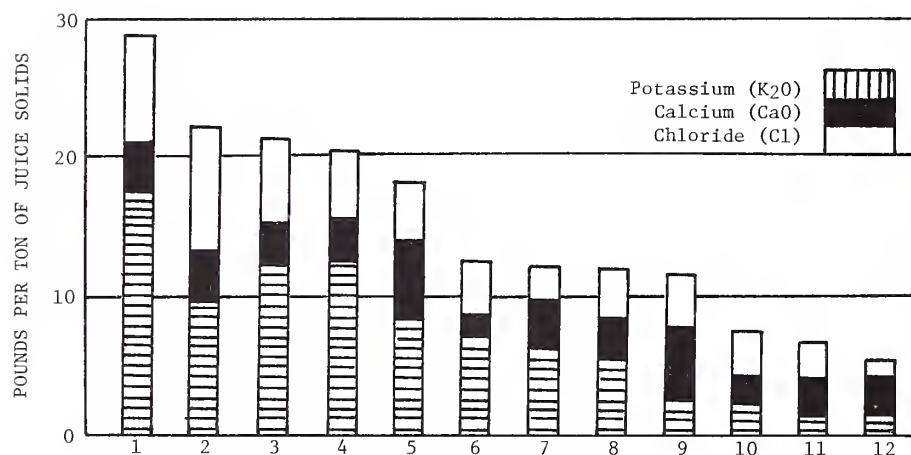


Fig. 2. Relative amounts of potassium, calcium, and chloride in Florida varieties grown on sandy land. Varieties used were: CP 56-63 (1), CP 57-603 (2), Cl 54-405 (3), Cl 41-223 (4), CP 62-374 (5), Cl 61-205 (6), Cl 59-1332 (7), Cl 61-5 (8), CP 63-588 (9), Cl 54-312 (10), Cl 54-336 (11), and Cl 54-378 (12).

Table 4. Concentrations of potassium, calcium, and chloride in the juice of 7 Florida cane varieties grown on muck soil.

Variety	Potassium (K ₂ O)		Calcium (CaO)		Chloride (Cl)	
	PPM in juice	lb/T solids	PPM in juice	lb/T solids	PPM in juice	lb/T solids
Cl 41-223	850	8.6	1195	12.0	485	4.8
Cl 54-312	1472	15.4	435	4.6	589	6.2
Cl 54-336	1576	15.4	295	2.8	550	5.4
Cl 54-378	2453	23.6	1024	9.8	911	8.8
Cl 54-405	1742	18.8	653	7.0	663	7.2
Cl 59-1332	648	6.4	782	7.6	524	5.2
Cl 61-205	1633	16.0	305	3.0	1114	11.0
Mean	1482		670		691	

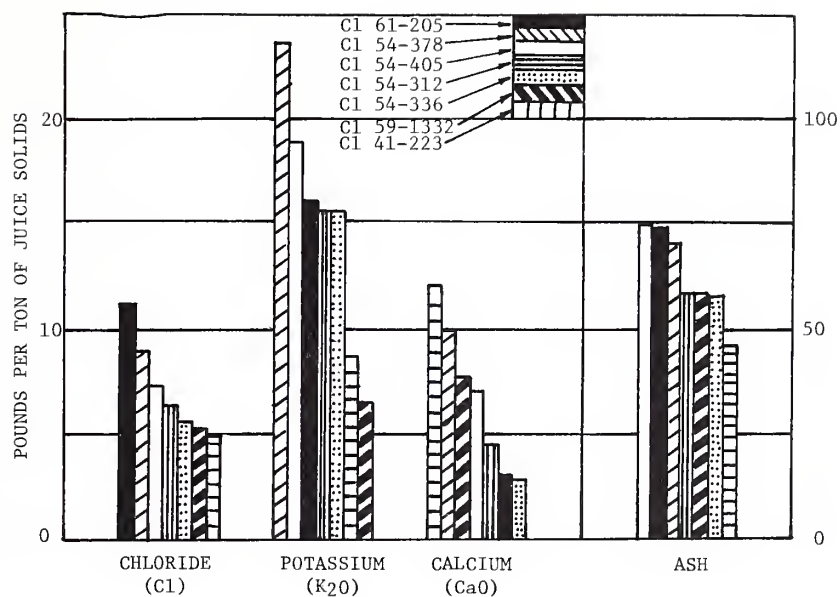


Fig. 3. Relative amounts of ash and melassigenic ions in the juice of Florida canes.

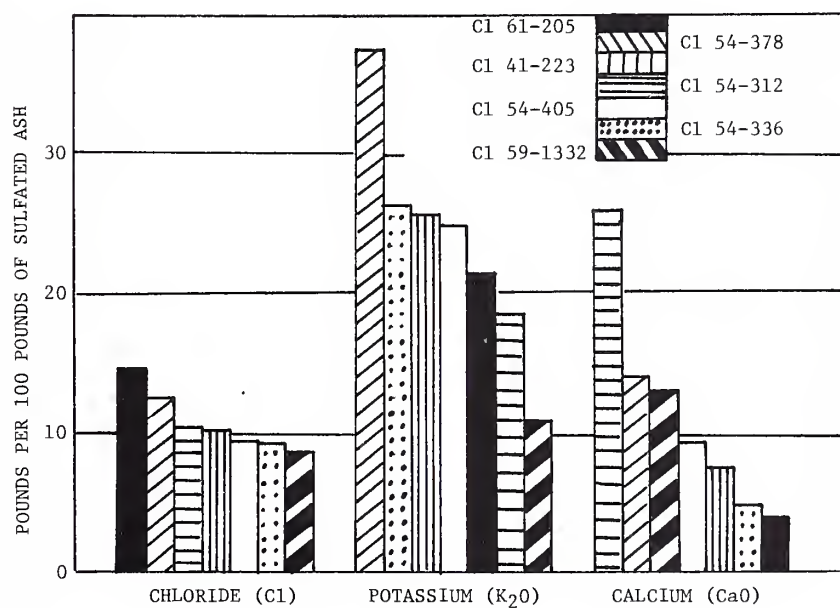


Fig. 4. Relative amounts of chloride, potassium, and calcium in the ash of Florida cane juices.

Since each molasses will contain its own characteristic complement of inorganic impurities determined by cane variety, soil composition, fertilizer practices, weather conditions, etc., it is obviously quite difficult to precisely assess the adequacy of molasses exhaustion in the factory. The concept of a standard purity as used to advantage in the European beet-sugar industry could be one answer to this problem (15). For the purpose of this treatment, the viscosity of the molasses is assumed to be the limiting factor in determining the final molasses purity. Once these optimum viscosity limits have been established for a particular factory operation, any given molasses sample is adjusted to these limits and then saturated with added sugar. The purity of this adjusted sample is the standard purity and represents the optimum exhaustion of the particular molasses with its own characteristic complement of impurities. The standard purity is then compared to the factory purity to judge how well the molasses has been exhausted. A factory purity appreciably higher than the standard purity indicates inefficient processing, while a lower value indicates perfect exhaustion within the limitations of the process. The time required for this procedure (several hours) is its main disadvantage and this probably limits its usefulness to occasional checks in practice.

Aside from its usefulness in understanding the fluctuations in final molasses purity, this information in a suitably amplified form should prove valuable for selecting varieties most suitable for particular fields or areas. From among those varieties already selected for high sugar content, good disease resistance, and suitable cold tolerance, the specific varieties yielding juice most conducive to efficient processing under a given set of conditions could be selected. For example, other factors being equal, a variety prone to accumulating a high level of chloride should not be planted in fields with high chloride contents. Thus, increased knowledge of the nonsugars present in the juice could be used to maximize sugar recovery and minimize processing problems, especially when dealing with problem land areas.

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POLYMERS IN CANE JUICE CLARIFICATION

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ABSTRACT

Evaluations of polymer flocculants on mud filtration and refinery-melt liquor have been presented previously at meetings in 1972 by the author and colleague (1, 2). Since 1959, different flocculants have been evaluated by the author for cane-juice clarification. Tests were carried out on a laboratory scale as well as in factory to allow parallel comparisons. Due to differences in molecular weight and molecular structure of polymers, plus variations in local conditions and cane varieties, the sedimentation characteristics of a polymer varies, depending upon the influence of the variables. More than 50 polymers have been tested - cationic, anionic and non-ionic - to compare with Separan AP-30. The most effective ones are all anionics.

INTRODUCTION

Synthetic polymers have replaced the natural flocculants (algin, soybean extract, gum arabic, etc.) used in the sugar industry for clarification purposes.

Polymers were first applied to raw cane juice. Then in the early 1960's, they were also used for conditioning cachaza in mud filtration. In more recent years, some polymers have been found to be good aids in refinery melt liquor as well as in clarifier-scum conditioning. Different flocculants have been evaluated by the author since 1959, with factory scale tests run in several sugar producing countries. This paper covers only the raw cane juice clarification. Evaluations of flocculants on mud filtration and refinery melt liquor have been presented previously at other sugar conventions (1, 2).

Flocculation was formerly considered to be the result of charge neutralization, i.e. by the addition of a substance carrying opposite charge to that carried by the particles in suspension. The recent investigations (3) show that charge neutralization is not the sole mechanism of flocculation, but that it functions rather as an aid to other mechanisms, such as bridging. That is why neutral or negatively charged flocculants (anionic polymers) are chosen for the flocculation of negatively charged suspension. Bridging takes place not only with non-ionic and anionic polymers, but also with cationic types. The adsorption of polymer molecule effects a bridge between two particles.

RAW JUICE CLARIFICATION

The functions of a good flocculant are:

- (a) to increase settling rate of insoluble solids;
- (b) to decrease mud volume;
- (c) to produce good clarity of clarified juice (low turbidity); and
- (d) to produce good filterability of mud, with good clarity of filtrate.

The laboratory tests were carried out with a row of 500-ml measuring cylinders, having a scale on the same level. Then the different flocculants were added into those cylinders, or same flocculant with different dosages.

For direct comparison, the limed-heated raw juice was collected from the process, and while stirring, poured into each cylinder from "0" to "X", rapidly stirring the juice and flocculant in each cylinder and marking the starting time. Then duplicates of each test series were obtained by reversing the pouring order from "X" to "0". The sum, or average, of two runs gave a good comparison of the series.

For years, Separan AP-30 has been considered as the most adaptable and consistent flocculant, under different local conditions, in cane juice clarification. From 1959 to 1963, several new polymers were available for evaluation. The following examples show the general results obtained during that period of time (Fig. 1 and 2).

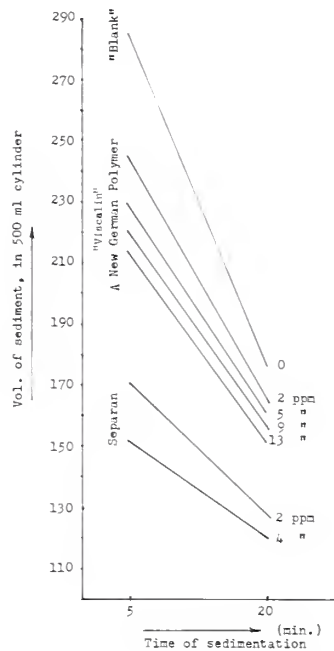


Fig. 1. Evaluation of new polymers vs. Separan AP-30 (Test Series: CG-0963-2).

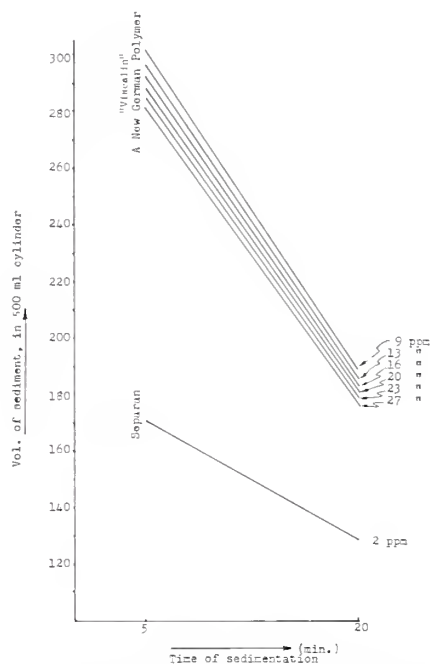


Fig. 2. Evaluation of new polymers vs. Separan AP-30 (on higher dosages) (Test Series: CG-0963-4)

Until 1965, two new German products were shown to be comparable or better than Separan AP-30. The laboratory tests almost always reproduced the same pattern of sedimentation curves (Fig 3 and 4).

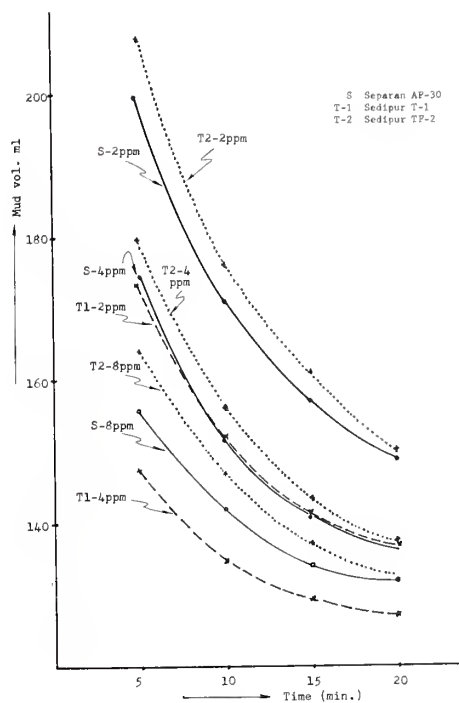


Fig 3. Separan vs. German T-1 and T-2. (Test Series: CG-0665-13. Average of ten series of duplicates.)

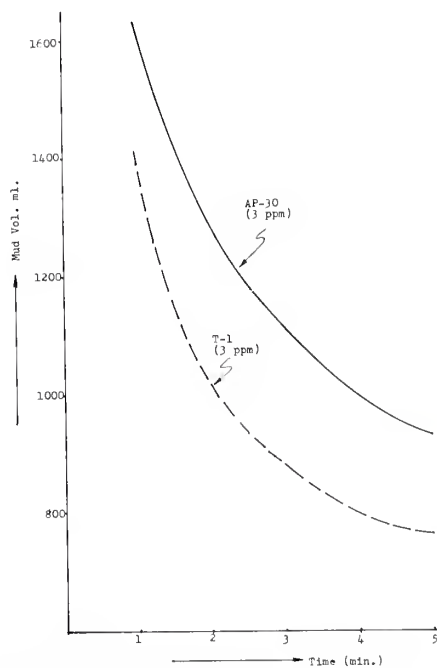


Fig. 4. Separan AP-30 vs. German T-1. (Test Series: CG-0665-15. Average of ten series of duplicates, during the first 5 minutes.)

The average of 10 series, each series with many duplicates, show that: (> = better than)

*T-1 (2 ppm) > S (2 ppm) > T-2 (2 ppm)

and that,

T-1 (2 ppm) ≥ S (4 ppm)
 ≥ T-2 (4 ppm)
 T-1 (4 ppm) > S (8 ppm)
 > T-2 (8 ppm)

*Where T-1 is Sedipur T-1

T-2 is Sedipur TF-2

and S is Separan AP-30

Comparison on the basis of quality of clarified juice was made from 10 series of duplicates. Color was determined for each juice sample before and after filtration. The difference between the two color readings was due to turbidity. The results are presented in Table 1.

Table 1. Comparison of juice clarity.

Polymer	Bx	Pol	Purity	Ash*	Color**		
					Bef. F.	Aft. F.	Diff.
"blank"	16.10	13.74	85.34	.685	86	75	11
AP-30	15.90	13.78	86.67	.666	81	73	8
T-1	15.90	13.78	86.67	.663	78	72	6
T-2	15.90	13.78	86.67	.676	82	75	7

*Conductivity ash

**Read at 100 (-log T₅₆₀)/5 Bx/3.4 cm

After confirming through the sedimentation rate and clarified juice quality that T-1 was superior to AP-30, the new polymer was applied in factory scale operation. With the facility of having 2 Dorr clarifiers (32 ft and 42 ft) in the same factory, and by interchanging the dosing of flocculants into the 2 clarifiers, the summation of results could be compared directly. Generally, the results from factory operation checked well with those obtained in the laboratory. But in several cases, especially during the summer months in Peru, the AP-30 showed to be more adaptable to abnormal juices than the T-1. The reasons could be due to the over-maturity of cane or micro-organism products that affected one polymer but not the other.

As more polymers became available, it was found that some flocculants may be more effective in the first stage of sedimentation than the others, but smoothed out and made little difference toward the latter stage (Fig. 5 and 6).

The sedimentation rate did not always follow a trend from increasing dosages of a polymer, but may reverse the effect, as shown in Fig. 7 and 8. This has also been observed by Hale, et al. (4). For one type of flocculant, the increase of dosage may give same result; while for another type, the result may be even worsened. This may be so for some types of juice, but not necessarily so for all types of juice.

The effect of molecular weight of flocculant on sedimentation rate has been studied by Linke and Booth (3) with results as shown in Fig. 9.

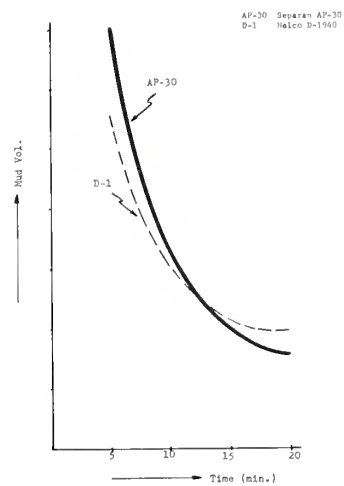


Fig. 5. Sedimentation characteristics, AP-30 vs. D-1 (2 ppm). (Test Series CG-1065-3)

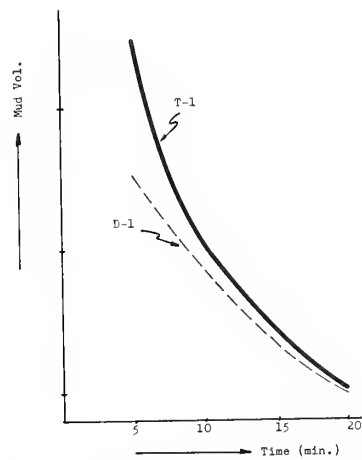


Fig. 6. Sedimentation characteristics, T-1 vs. D-1 (2 ppm). (Test Series CG-1065-8)

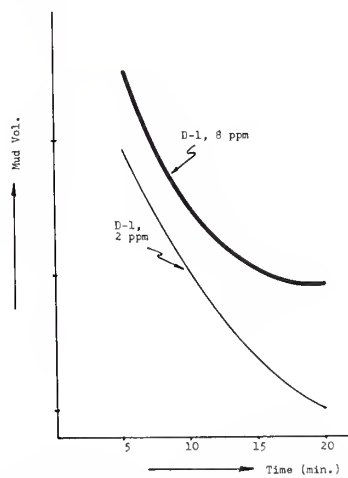


Fig. 7. Sedimentation characteristics, D-1 on different dosages. (Test Series CG-1065-8)

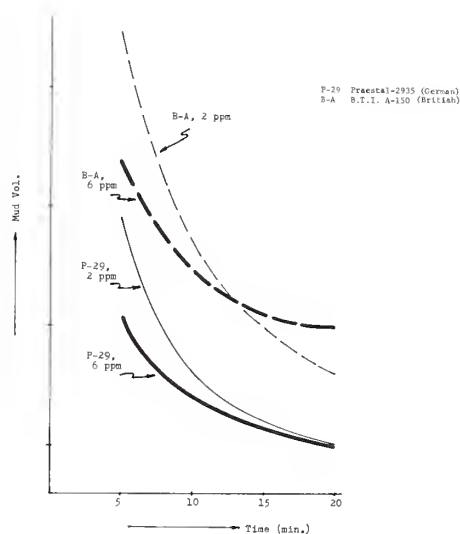


Fig. 8. Sedimentation characteristics, B-A & P-29 on different dosages. (Test Series CG-0470)

Mol. weight: A 5,000,000
B 2,000,000
C 1,000,000
D 500,000

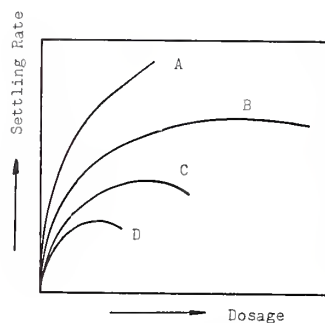


Fig. 9. Effect of molecular weight of polyacrylamide on settling rate of silica dispersion. (Linke & Booth)

An observation was also made on the clarity of clarified juice vs. rate of sedimentation. It was found that they were not always correlated. For instance, in the effectiveness on sedimentation, the order was T-1 > AP-30 > D-1; but in the effect on clarity of juice, the order was D-1 > T-1 > AP-30. These relationships can be seen in Table 2.

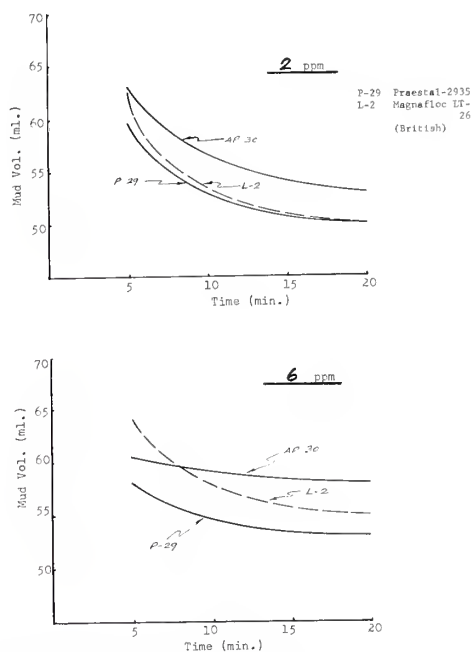
Besides those of the Separan series, other polymers tested were series from Sedipur, Reten, Hodag, Zuclar, Praestol, Rohm & Haas, Magnafloc, Nalco, etc. altogether more than 50 products.

Among all being evaluated, there are 2 flocculants showing comparable or better than the current AP-30 in all respects, especially in their adaptability to different juice/earth-particle quality. These 2 polymers were tested in Peru in 1967 under laboratory conditions. Then they were applied in factory operation (7000 ton cane/day), using 2 Dorr Clarifiers to compare in parallel (with duplication by shifting the dosing of polymer) against AP-30. Results obtained checked closely with the laboratory data. These polymers were then tested by the author in several mills in South America, where they also demonstrated their superiorities (Fig. 10).

Table 2. Comparison of juice clarity.

Polymer	Bx	Pol	Purity	Ash*	Color** (Clarif. J.)		
					Before filt.	After filt.	Diff.
"blank"	16.69	13.73	82.26	.618	95	58	37
AP-30	16.54	13.70	82.83	.591	69	54	15
T-1	16.56	13.73	82.91	.588	69	53	16
D-1	16.53	13.72	83.00	.582	63	52	11

*Conductivity ash.

**Read at 100 $(-\log T_{560})/5^\circ\text{Bx}/3.4\text{ cm}$ Fig. 10. Two new polymers vs. Separan AP-30 (CG-0470)
(Factory operations confirmed their superiorities)

During the 1972 crop, a series of comparison was again carried out. There were 3 new polymers found to be comparable to Separan AP-30, (Figs. 11, 12, and 13); polymer L-2, which was previously found to be better than AP-30, was used as the "check".

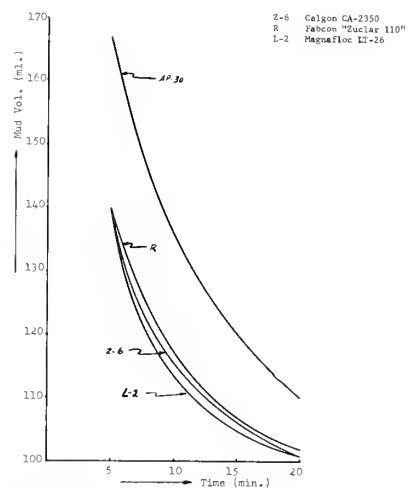


Fig. 11. New polymers compared with Separan AP-30. (Normal mixed juice during dry days.) (Averages of many series with compensation of pouring order.)

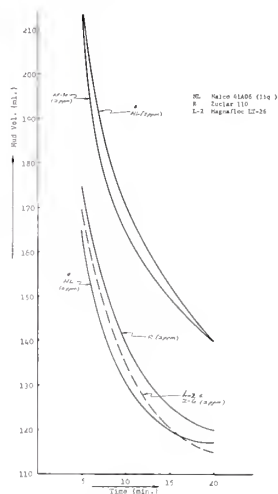


Fig. 12. New polymers compared with Separan AP-30. (Muddy mixed juice during rainy days.)

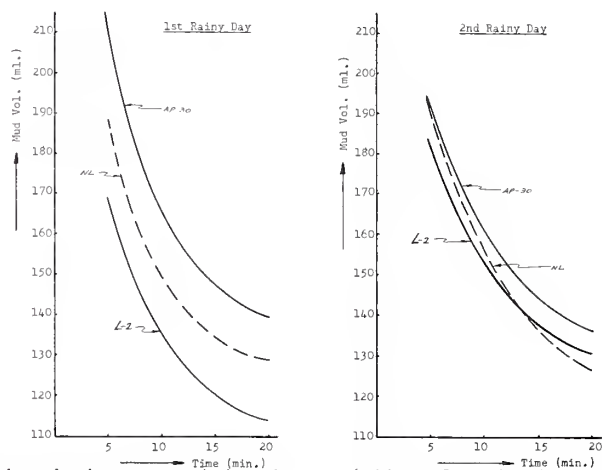


Fig. 13. Muddy juice during two raining days. (all on 2 ppm) (Average of series.)

DISCUSSION

Due to influencing factors such as cane variety, growth conditions, mud particles and characteristics, etc, the effectiveness of a flocculant may vary from country to country and from juice to juice. One type of polymer was found superior to AP-30 in Australia, but was not found to be superior in Peru.

Different polymers show different sedimentation characteristics. Some gave "shock" effect in the beginning, but slowed down afterward.

Some flocculants gave good clarity of juice, but were poor in the sedimentation. This was also observed by Dunford, et al (5).

Increasing the dosage of a flocculant did not necessarily increase the effectiveness in sedimentation; and in many cases, it reversed the effect. This was also observed by Hale, et al (4). During rainy days when juice was difficult to clarify, the increase of dosage may be effective for one flocculant but not the others (Fig. 13 and 14).

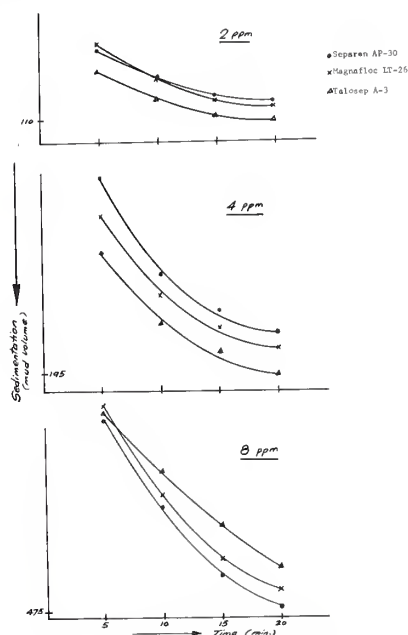


Fig. 14. Separan AP-30 vs Magnafloc LT-26 and Talosep A-3 (With juices of different mud content.)

Increasing the molecular weight of a polymer may reduce the tendency of reverse sedimentation effect. The other important factor is the molecular structure of the polymer.

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VACUUM PAN PERFORMANCE

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ABSTRACT

This paper deals with the importance of having the vacuum pan station provided with a suitable source of heat that takes into account not only the economy of steam but also the proper performance of the vacuum pan as recoverer of sucrose in crystal form.

We all know that there are many aspects to be dealt with when talking about vacuum pan performance; but all of them are aimed to insure the principal aspect, which is circulation.

During the history of sugar-making, the design of the vacuum pans has been greatly improved to get maximum circulation. Optimum efficiency in circulation is obtained only on those vacuum pans equipped with mechanical circulators. Unfortunately, most of the vacuum pans presently operating in the sugar factories are not equipped with mechanical circulators.

The literature about the advantages derived from the mechanical circulators is quite ample and nobody would dare question it.

We do not need to go into the matter of mechanical circulators, but we do wish to bring it up, because all that has been discussed to prove the advantages and/or necessity of mechanical circulation leads us to the understanding of what we are doing with vacuum pans that, for one reason or another, perform with a poor circulation.

We are not going to go into the matter of vacuum pan design. We are going to point out the common case of vacuum pans with good design, but improperly operated, mainly dealing with the steam supply in the vacuum pan station.

In Fig. 1, we show how the circulation of the massecuite is taking place in the vacuum pan.

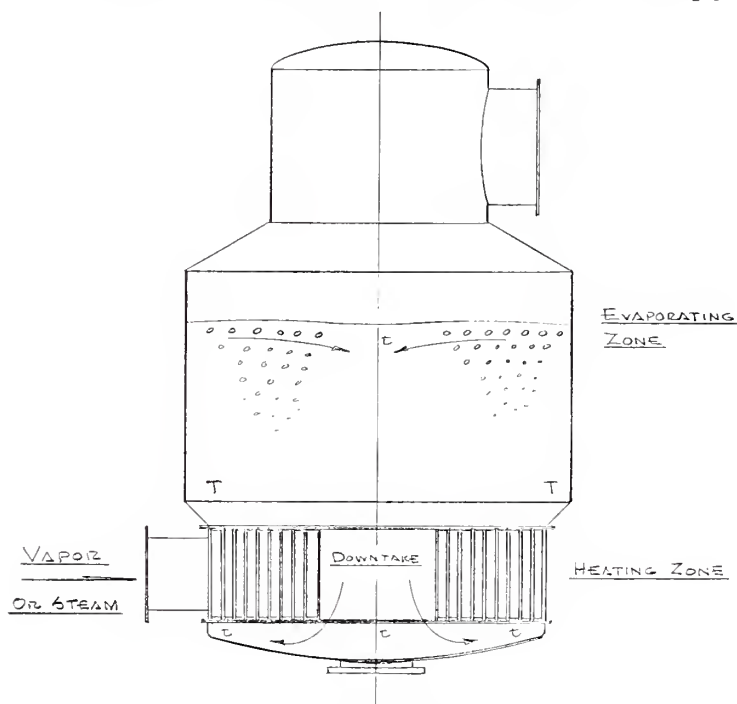


Fig. 1. Diagram of the circulation of the massecuite in a vacuum pan.

It is induced or forced by the vapor bubbles formed by heat in the tubes of the calandria that head their way out to the area of lower temperature at the top of the massecuite level. As the bubbles of steam go out at the top level, the massecuite turns heavier by the loss of steam bubbles, air and gases, and temperature, of course. Then it finds its way down by gravity through the downtake of the calandria in order to come up again through the calandria tubes where new vapor bubbles will be formed by heat, and the cycle will be repeated again and again. So, we see that the mechanism of circulation depends on the temperature difference, $T - t$.

When the massecuite is passing through the calandria tubes, we cannot avoid burning some sugars, especially reductor sugars, forming some caramel with detrimental effects on sucrose recovery and sugar quality. Hence the necessity of performing this operation as fast as possible. The destruction of sugars by heat is not only a matter of degree of temperature, but greatly, as well, a matter of time during which the sugar product is held at high temperature.

In Fig. 2 we can see the time curve found by the late Mr. Alfred Webre for a vacuum pan with natural circulation while making a C strike. We can see how after 3 hr. of boiling the circulation speed comes down to practically zero. And, it is not uncommon, believe me, to find sugar factories where C massecuite strikes take 6 or more hours to be completed due to poor circulation by lack of proper temperature difference, $T - t$. And all that time, while the massecuite has been practically still, sugar is being destroyed.

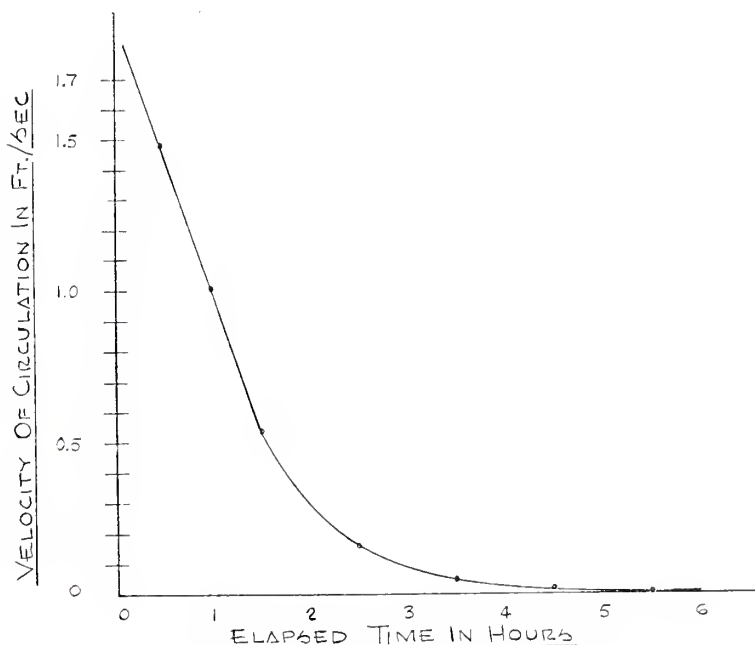


Fig. 2. Time curve for a vacuum pan with natural circulation during a C strike.

From here, the great importance born by the source that supplies the temperature difference, $T - t$, of Fig. 1 that is the steam admitted to the calandria.

Many times, for the sake of steam economy, the vacuum pan performance is sacrificed by supplying this station with extremely low temperature vapors, which make the vacuum pans work slowly. We agree with the saving of steam, but only up to the point where it does not mean destruction of sugar due to excessive boiling time of massecuite boiling. As a matter of fact, steam is generated in a sugar factory to make sugar, not destroy it, and that is what we do when we supply the vacuum pans with very low-temperature steam.

We do not mean that vacuum pans cannot be heated with vapors bled from a previous stage of evaporation. Indeed, it should be done in a well-designed evaporating system. But these vapors have to be of enough pressure to enable them to supply proper temperature to ensure fast circulation of the massecuite in the vacuum pan.

As an aid to improve circulation, especially when heating with vapors of less than 10 psig, all vacuum pans with natural circulation should be equipped with the Claassen system of steam injection shown in Fig. 3, either in conjunction with the feeding, or separately.

With this system, which the author has used successfully for a long time, we cannot expect to obtain the same advantage as with the mechanical circulation, but we do obtain a great improvement when compared with the vacuum pans of natural circulation without this system, both in capacity (cubic feet of massecuite boiled by the hour) and much less caramelization (destruction of sugars) due to the faster circulation.

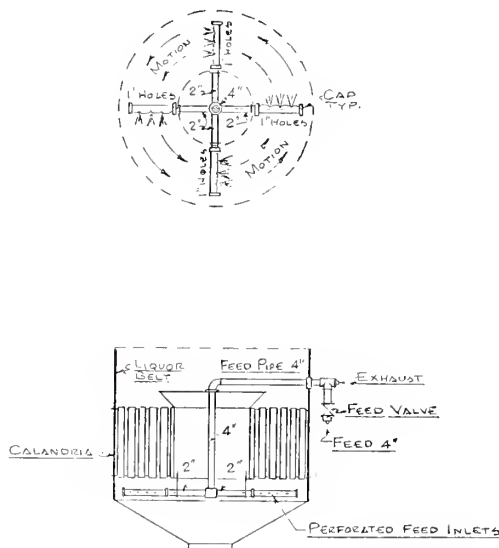


Fig. 3. Diagram of the Claassen system of steam injection to aid circulation in the vacuum pan.

CONTROL OF GRAIN SIZE IN REFINED SUGAR

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ABSTRACT

By using the size distribution of sieving analyses of the (MA/CV) method, practical results can be obtained in the control of grain size in refined sugar. The (MA/CV) is a concise method of reporting results of a sieving test which is based on the assumption that most samples of sugar have a normal size distribution (found to be true in practice). A plot of the accumulative percentages retained after shaking by a series of sieves against sieve aperture on arithmetic probability paper will give a straight line. The control of grain size was established by comparing the results obtained against the straight line which corresponds to the standard size desired. The advantage of this method described is in the control of crystallization and handling of the strikes in the vacuum pans.

An important phase in controlling refined sugar quality is grain size. No matter what method of reporting is used, the grain size is determined by mechanically sieving a suitable size of sample, usually 100 g, in a nest of sieves with apertures of varying sizes.

H. E. C. Powers of the Tate and Lyle organization introduced a method of reporting grain size known as the Mean Aperture/Coefficient of Variation System, or MA/CV.

The MA/CV is a concise method of reporting results of a sieving test and is based on the assumption that most samples of sugar have a normal size distribution, which has been found to be true in practice, so that a plot on arithmetic probability paper of the cumulative percentages retained by a series of sieves will give a straight line for a normal distribution from which the mean aperture (MA) and coefficient of variance (CV) can be derived.

The mean aperture is defined as the aperture corresponding to the intercept of the graph with the 50% line projected from the ordinate. It must be noted that the mean aperture is not the mean particle size but the aperture through which 50% of the sample will pass.

The coefficient of variance is defined as the standard deviation expressed as a percentage of the mean aperture. In a normal distribution, 15.9% of the sample is larger than the mean plus 1 standard deviation, and similarly, 15.9% is smaller than the mean minus 1 standard deviation. Therefore, the standard deviation may be obtained by noting the aperture size at which the 15.9% projection, usually approximated to 16%, intercepts the graph and subtracting the mean aperture from it.

The advantage of this method of determining sugar size is that the size distribution is defined by 2 quantities, which are quite independent of the sieves used.

The sugar sample is divided until approximately the 100 g required for the analysis are obtained. When the sieving is completed, the sugar remaining in each sieve and that passing through the bottom mesh is collected and weighed. Each fraction is expressed as a percentage of the original sample, and the cumulative percentage held in each sieve is plotted against the sieve aperture with a straight line drawn through the points.

The mean aperture is obtained by noting the aperture corresponding to the intersection of the graph with the 50% horizontal. The coefficient of variance is calculated by subtracting the mean aperture from the aperture corresponding to the intersection of the graph with the 15.9% horizontal and expressing the difference as a percentage of the mean aperture. In practice, it is usually more convenient to use 16%.

Then, the coefficient of variance is calculated by the formula:

$$CV = \frac{(16\% \text{ aperture} - MA)}{MA} \times 100$$

H.E.C. Powers finds that the MA/CV figures are readily understood by panmen, and this is confirmed by the panmen at Moore Haven Sugar House.

Acceptance of the Powers method has been widespread but by no means universal. The British National Committee and Australia both approved the MA/CV method, and it is tentatively recommended by ICUMSA. Many beet-sugar companies in the United States have adopted it for refined sugar. The majority of cane sugar refineries in the United States, however, offer the objection that MA/CV does not give adequate information for the coarse and fine ends of the distribution, the portions of the grain-size scale of greatest interest to the commercial user of refined sugar.

A practical method introduced by the author at Glades County Sugar Growers Cooperative for grain-size control in refined sugar consists of comparing the graph of the sugar obtained with the graph corresponding to the grain-size standard desired. Then, according to the results obtained by the comparison, we can vary the quantity of sugar powder used in the full seeding system of boiling a footing strike, depending on what final grade of refined sugar is expected.

This practical method has permitted an accurate control of the grain size at the refinery.

Typical examples of this method of control are shown in figures number 1, 2, 3, and 4.

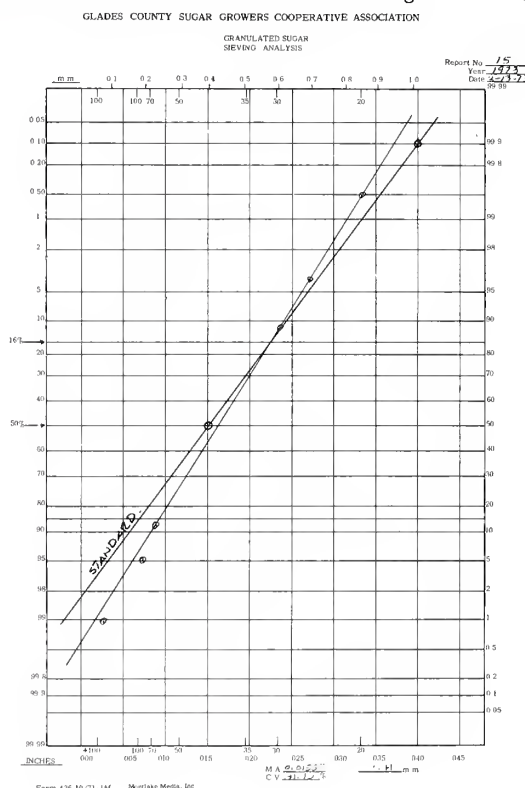


Figure 1. Typical graph of sugar size analysis.

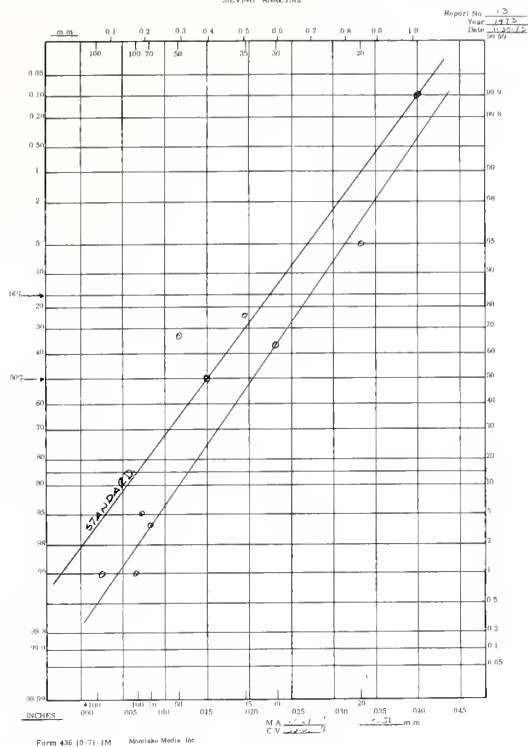


Figure 2. Typical graph of sugar size analysis.

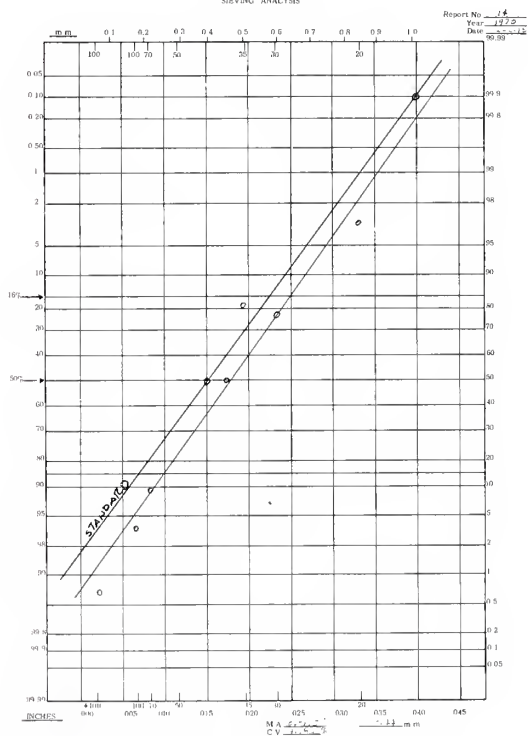
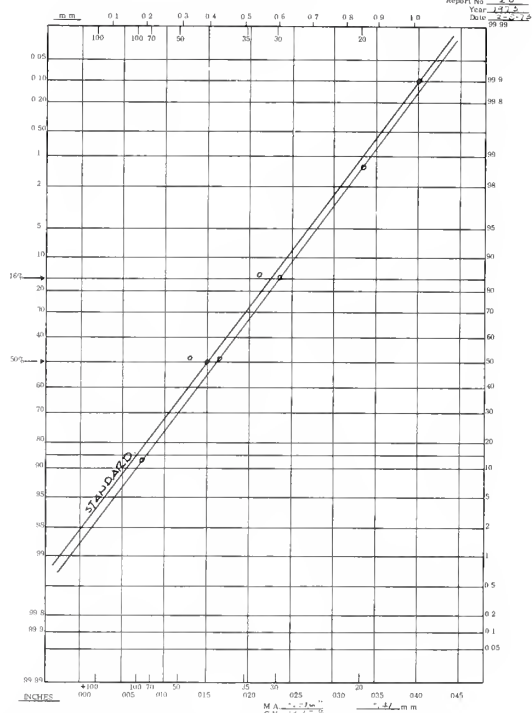


Figure 3. Typical graph of sugar size analysis.

GLADES COUNTY SUGAR GROWERS COOPERATIVE ASSOCIATION

GRANULATED SUGAR
SEIVING ANALYSIS

Report No. 20
Year 1972
Date 10/12



Form 436 10/71-1M Muntlake Media, Inc.

M.A. = $\frac{W_{\text{retained}}}{W_{\text{total}}} \times 100$
C.V. = $\frac{W_{\text{retained}}}{W_{\text{total}}} \times 100$

Figure 4. Typical graph of sugar size analysis.

THE ACTION OF POLYMERS IN THE FABRICATION OF REFINED SUGAR

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ABSTRACT

Polymers have been in use in the sugar industry for over 15 years in the clarification of cane juice and the agglutination of muds in the rotary vacuum filters. With the proper application of polymers in the sugar refining process, clarified liquors of such superior quality are obtained that, without any additional clarification and filtration equipment, it is possible to increase the capacity of those departments by 25%. The benefits of applying polymers to this part of the refining process are also reflected in the amounts of chemical products required as well as in the use of steam and in the consumption of water for the filters. A beneficial secondary reaction occurs when the muds from the refining clarifiers are returned to the raw sugar factory and aid in the clarification of the raw juices, in obtaining more brilliant defecated juice, and in decreasing the amounts of chemicals needed here.

The coagulants used in the sugar industry are polymers. They are very similar to the well-known materials so widely used in daily life such as teflon, polyethylene and diakon.

Polymers have been used in the sugarcane industry for over 15 years in the clarification of cane juices and the agglutination of muds in the rotary vacuum filters.

The increase of agricultural mechanization has forced 95% of the sugarcane industry to use polymers. Without them the capacity of clarification and filtration would have had to increase over 30%.

In the making of refined sugar, polymers have been used for only 5 years in the process of clarification. The coagulant was used with such success, in a plant where an increase of the capacity of clarification and filtration by 25% was considered, that the change became unnecessary. It was possible to increase production without any increase in equipment from 250 to 350 tons of refinery sugar per day after the coagulant was used.

Ten pounds of the coagulant were dissolved into a 400 gallon tank of water at 170 F with air bubbling through to insure a homogeneous solution. The reason for this solution was to insure the coagulant's dispersal into the raw liquor and to agglutinate the impurities.

A proportional pump was used to introduce the polymer into the raw liquor in the clarifier feeder tanks at a rate of 6 to 8 ppm.

The clarifier aerator pumps were stopped to avoid breaking up the polymer molecules as it was proven that when the pumps were in operation scums were not produced.

It was found that by using 0.06 lb of phosphoric acid per 100 lb of refinery sugar produced and a pH of 7.5 in the raw liquor one obtained optimum results, and the consumption of carbon and filter aids diminished by 35%.

The efficient action of the polymer in the clarification stage prolongs the cycle of the filters and lessens the need to wash more filters, which represents a savings in water vital to this factory which must operate during the dry season. Using the polymer in the clarification stage allows the filters to operate at a higher density and consequently realizing a savings in steam in the pans floor.

The final secondary benefits are produced when the raw sugar factory blends into the raw juice the scums taken from the refinery clarifiers. The scums carry sucrose, phosphate salts and the polymer, all beneficial products to the process of clarifying the raw juice. The sucrose is recovered, the polymer diminishes the use of coagulants, and the phosphate salts diminish the use of lime.

THE USE OF INSTRUMENTATION IN THE SUGAR INDUSTRY

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ABSTRACT

Instrumentation in the sugar industry can be related to solving manufacturing problems in the areas of costs and quality control. Our experience in the field of automatic brix control show this to be true. By automatically controlling the brix, we are able to save considerable time and fuel, which is to say, money. By use of a differential pressure transmitter, there are many ways that we can obtain good, dependable indications of density, but we have selected 2 methods to illustrate our point - one with the density chamber and the other with the bubbler system.

We realize that most of you have been working in the sugar industry for many years, and there is probably very little that we can say to add to your knowledge, but we would like to pass along our experiences in the areas of controlling costs and quality through the use of instrumentation wherever possible.

We know that by using the hydrometer we can accomplish about the same end as with automatic controls, but the important point that we want to make here is that a great deal of money is lost by not continuously checking the specific gravity.

A sugar boiler will probably require a Baume of 30° to 32° on the liquor coming into the vacuum pans. This will cut the boiling time so that you will save not only on labor and steam, but also in evaporating water needed to bring the liquor to the desired density; in other words, to raise the percent sugar or pure sucrose by weight in solution at 17.5 C.

The procedure is to measure the differential pressure through a very sensitive pressure transmitter with a known height between the low and high pressure connections, using the formula -

$$\frac{RX}{\Delta d} = h,$$

where RX is the range on the DP cell, and Δd is the difference between specific gravity at minimum and maximum degrees Baume to be analyzed, and h is the difference in inches of water column between the high and low side connection.

Specifically, our RX, or range on the DP cell, must be very small, as very small variations are being sensed. This is the main reason that the quality of an instrument is of such great importance. Also of importance is the distance between the low and high side connections since in most cases the space available is limited.

The differential on specific gravity will give us the accuracy of control that we want to maintain; so if we are looking for a control with a narrow band, we must remember the 2 other figures in the equation in order to bring a control within acceptable limits.

Now, let us assume that our needs dictate a control of 32° Baume, and the distance between the tubes (h) is about 60 inches; our RX or DP range should be 6.83.

Another important factor is the use of the proper size of valve, or valves if we have a 2-valve system or a recirculation valve.

Suppose we use 2 valves to add water or juice to the melter, these 2 valves should be controlling from 3-9 psi full open on the small valve, and 9-15 psi full open on the large valve. This gives us more accurate control. Again, it is important to obtain a very narrow proportional band in order to stay within .50% of one degree.

How good should a control system be? This depends on how much you want back. First of all, in brix control you want to save money during the process, so, if you want to avoid expending a few extra hours of labor and, at the same time, save steam and oil, this is all that counts; but never leave the control on manual operation because a man just cannot be as efficient as automation.

On the other hand, the importance of automatic instrumentation is shown in quality control, which gives us a more uniform product. We see this in terms of producing a more accurate control on production costs. We all know that if our brix indication is lower than what is required, we must expend more time on the vacuum pans to evaporate the water, and use more steam and labor. But, if our brix control is accurate, we may be able to complete more strikes and produce more in the same amount of time.

The differential pressure transmitter is a force balance instrument which will convert a flow signal from a transducer to a mechanical movement applied to a rod. By changing this movement as an input to a relay or oscillator, we can obtain a pneumatic or electronic signal as psi or current output.

Let us review our points: Automation gives better control and quality, saving us money and energy. And, by controlling the brix within a very narrow band, we can keep within a 0.5° Baume.

As an example, we recommend using a brix between 45-65, or 24.63° to 35° Baume, which will give us a differential specific gravity at 20/40 C. of:

$$\begin{array}{r} 1.3163 \\ 1.2025 \\ \hline 0.1138 \end{array}$$

By using about 60 inches as h, we find a range RX = 6.83 inches, which will give us an output of 3-15 psi from minimum to maximum deviation. Therefore, if we adjust our proportional band, we will see that we get a wider indication of about 5 inches on our charts for only 20 degrees span, or 1/4 inch for each degree. If we have a narrow proportional band, we will be able to control our brix to within 0.5° Baume.

The bubbler system will basically be the same because the distance between the low side tube and the high side will be our h value. Our RX value will be given by the formula

$$\frac{RX}{\Delta d} = h$$

We will introduce both high and low side tubes into a pipe about 4 or 5 inches in diameter. On top of these 2 tubes, we should provide manifold connections and flushing water in order to clean the system when it gets clogged.

This system will give us very good control and easy maintenance in addition to continuous inspection. It will be controlled by 2 valves - one directly to our tank, and the other to recirculation.

CONTROLLED PHOTOPERIODISM IN BASIC SUGARCANE BREEDING ^{1/}

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ABSTRACT

Under natural photoperiods, sugarcane (*Saccharum* spp.) breeding stocks flower at widely different times. At Houma, daylength is artificially controlled to induce simultaneous flowering of breeding stocks. In 2 treatments, mid- to late-season flowering commercial breeding canes were induced to flower 6 to 2 weeks earlier than normal by control of daylength on declining and fixed + declining regimes. In a third treatment with 9-hour days, the flowering of *S. spontaneum* L. variety Tainan (2n = 96) was delayed 54 days. As a direct result of controlled photoperiodism, 41 crosses were made. These crosses accounted for 29% of the total crosses made and 20% of the number of viable seeds produced during the 1973 breeding season at Houma.

INTRODUCTION

Many breeding stocks required to broaden the genetic base for sugarcane improvement do not flower at the same time under natural conditions. The natural range of flowering of sugarcane and related genera that cross with sugarcane makes it impossible for breeders to make special crosses without special treatment. Although asynchronous flowering of breeding stocks derived from a common genetic base poses difficulties in making commercial-type crosses, much greater problems are encountered in basic breeding where extremely variable germplasm with wide-ranging flowering habits is required for long-term sugarcane improvement. However, variations in the time of flowering of both commercial and basic breeding stocks have been partly overcome by artificially devised photoperiod treatments designed to either promote or retard the time of flowering and increase the efficiency of making the desired crosses.

The role of photoperiod treatment in sugarcane breeding has been discussed by sugarcane breeders and physiologists around the world. Sartoris (10) showed that *Saccharum spontaneum* L. NG 28-292 flowers on a 13-hr daylength, but not on 10-, 12-, 14-, or 16-hr daylengths. Brandes and Matz (1) treated Co 281 with graduated, artificial daylengths, made the variety flower early, and crossed it with an early-flowering F₁ hybrid of Turkestan 'wild' (*S. spontaneum*). Lee and Lin (8) observed that an unnamed variety of *S. spontaneum* flowered on 12-hr daylengths, but flowering was delayed by 9- and 15-hr daylengths and inhibited by 6-hr daylengths. Using decreasing daylengths patterned after those that induce sugarcane to flower naturally in Hawaii, Chilton et al. (2) obtained midsummer flowering in 5 sugarcane varieties that normally flower much later.

Factors affecting the flowering of sugarcane, especially the role of the photoperiod, were evaluated experimentally by Vijayasaradhy and Narasimhan (11), Coleman (4), Daniels (5), Clements and Awada (3), George and Lalauette (6), Paliatseas (9), and James (7). Workers agree that photoperiod is the key factor influencing the behavior of sugarcane with regard to flowering. They agree that age of cane, temperature, soil moisture, and soil fertility at the time of inductive daylengths interact with the photoperiod to enhance, retard, or prevent transformation of the sugarcane apices from vegetative to reproductive growth.

MATERIALS AND METHODS

On November 15, 1972, single-bud cuttings of selected parental varieties were planted in flats of sterilized soil in the greenhouse. Two months later they were transplanted to 10-gal cans on carts in the breeding greenhouse. On April 15, 1973, the cans were moved from the greenhouse onto outdoor racks and on July 31 onto the carts of the photoperiod house (Fig. 1). All of the treatments were started on August 1, 1973. Sunlight was used for all treatments.

^{1/} Research is done in cooperation with the Louisiana Agricultural Experiment Station.



Fig. 1. Basic sugarcane breeding facilities at Houma, La. Photoperiod house in right background.

Before the photoperiod treatments were started, each can culture was fertilized every 15 days with about 34 g of liquid 12-6-6 fertilizer containing trace elements. Despite special attention given to maintaining optimum soil moisture conditions, not all of the cans in the experiment could be kept well drained. Weak suckers were removed so that when treatment began, only mature stalks remained.

Experiments 1 and 2 were designed to promote flowering in commercial breeding canes so that they might be crossed with early-flowering *S. spontaneum* varieties and early-flowering F₁ and BC₁ clones from new lines. Experiment 3 was designed to retard the flowering of early-flowering wild canes so that these might be crossed with late-flowering commercial-type recurrent parents and BC₂ and BC₃ clones from new lines.

In Experiment 1, 24 commercial breeding canes were subjected to declining daylengths (1 min/day) for 50 days, beginning with 12 hr 32 min on August 1 and ending with 11 hr 42 min on September 20. Thereafter, the canes were left outdoors until they flowered.

In Experiment 2, 17 commercial breeding canes were subjected to fixed daylengths of 12 hr 25 min for 42 days. At the end of that time, tassel emergence appeared to be slowing, so the canes were put on daylengths declining 1 to 2 min/day, beginning with 12 hr 24 min on September 13 and ending with 11 hr 54 min on September 30. Thereafter the canes were left outdoors until tassels emerged.

In Experiments 1 and 2, the daylength was measured from precisely specified time in the morning at which canes were removed from the photoperiod house until sunset.

In Experiment 3, 9 early-flowering varieties and 1 late-flowering variety of *S. spontaneum*, 2 US varieties, and 3 mid-season flowering commercial canes were subjected to noninductive 9-hr daylengths for 50 days, beginning August 1. In this experiment, the canes were kept in darkness in the photoperiod house from 4:30 pm to 7:30 am. After September 20, this treatment was discontinued and the canes were left outdoors.

Controls of most varieties in the experiments were kept on the carts of the breeding greenhouse, exposed to the natural photoperiod, and protected from night temperatures below 18 C. Controls of the early-flowering wild canes were kept on outdoor racks.

RESULTS

Experiment 1.

Seventeen of the 24 varieties were induced to flower 4 to 6 weeks earlier than the controls by a declining (1 min/day) daylength for 50 days (Table 1). The date of first flower emergence was 45 days earlier than that of controls for L 61-67 and L 62-96 and 27 days earlier for CP 69-380. The 6 CP varieties that had no controls in this experiment normally flower from mid-November to late December in the greenhouse at Houma. Therefore, they, too, were probably induced to flower early during the 1973 season.

Table 1. Flowering behavior of 24 commercial breeding canes subjected to photoperiod regime* of 1-min declining daylengths, 1973 breeding season.

Variety	Stalks treated (no.)	Stalks flowered %	Date of first flower emergence		
			Treated	Control	Treated - control (days)
CP 48-103	11	100	10/19	11/26	-39
CP 52-68	10	100	10/10	11/17	-38
CP 57-614	14	100	10/10	no control	-
CP 65-357	13	100	10/15	11/18	-34
CP 66-491	10	100	10/12	no control	-
CP 69-312	5	100	10/24	no control	-
CP 69-349	14	100	10/11	no control	-
CP 69-380	10	100	10/22	11/18	-27
CP 69-384	12	100	10/14	11/19	-36
CP 70-305	7	100	10/17	11/23	-37
CP 70-310	14	71 ⁺	10/15	11/20	-36
CP 70-317	15	100	10/11	11/19	-39
CP 70-321	15	100	10/15	11/27	-43
CP 70-327	10	100	10/16	11/29	-44
CP 70-330	11	100	10/17	no control	-
CP 70-337	12	100	10/14	no control	-
CP 70-378	11	100	10/14	11/19	-36
CP 70-394	17	100	10/15	11/21	-37
CP 70-401	6	83	10/20	11/23	-34
Cl 47-83	11	0	aborted	no initials	-
L 61-67	9	100	10/14	11/28	-45
L 62-96	8	75 ⁺	10/15	11/29	-45
L 65-69	9	100	10/18	11/29	-42
NCo 310	13	62 ⁺	10/18	11/16	-29
Total or ave.	267	91	-	-	-

*Start of treatment, August 1, 1973; end of treatment, September 20, 1973.

⁺Poorly drained cans in which stalks were weakened.

Experiment 2.

Treated canes also flowered earlier than the controls in this experiment where the canes were subjected to a fixed daylength of 12 hr 25 min for 42 days and then put on declining (1 to 2 min/day) daylengths for 18 days (Table 2). The date of first flower emergence ranged from 34 days earlier for CP 57-526 to 5 days earlier for NCo 310. The differences in flowering dates between treated and controls were not as great as in Experiment 1, even for the 8 varieties common to both experiments.

Table 2. Flowering behavior of 17 commercial breeding canes subjected to photoperiod regime* of fixed + declining daylengths, 1973 breeding season.

Variety	Stalks treated (no.)	Stalks flowered (%)	Date of first flower emergence		
			Treated	Control	Treated - control (days)
CP 48-103	6	100	11/12	11/26	-14
CP 57-526	6	33 ⁺	11/16	12/19	-34
CP 61-39	5	100	11/9	11/23	-15
CP 65-357	5	100	11/6	11/18	-12
CP 66-491	7	100	11/11	no control	-
CP 69-302	9	89 ⁺	11/13	no control	-
CP 69-373	8	100	11/16	11/23	- 7
CP 70-300	14	100	11/7	11/30	-23
CP 70-312	11	81 ⁺	11/8	12/4	-27
CP 70-321	17	82 ⁺	11/15	11/27	-12
CP 70-332	11	82 ⁺	11/14	11/30	-16
CP 70-383	14	100	11/14	no control	-
Cl 47-83	6	0	aborted	no initials	-
L 61-67	11	100	11/10	11/28	-30
L 62-96	4	100	11/8	11/29	-32
L 65-69	5	100	11/11	11/29	-29
NCo 310	9	67 ⁺	11/11	11/16	- 5
Total or ave.	148	86	-	-	-

*Start of treatment, August 1, 1973; end of treatment, September 30, 1973.

⁺Poorly drained cane in which stalks were weakened.

Experiment 3.

The fixed 9-hr daylength to which these canes were subjected completely inhibited flowering in all of the varieties except in *S. spontaneum* varieties SES 278, SES 351, Tainan (2n = 96), and US 56-8-2 (Table 3). SES 278 and SES 351, which were in early boot stage when the treatment began, flowered too early to cross with commercial varieties. However, the flowering of Tainan (2n = 96) was delayed 54 days by the short-day treatment.

Table 3. Flowering behavior of 3 commercial, 2 US, and 10 *Saccharum spontaneum* canes subjected to a 9-hr day photoperiod regime*, 1973 breeding season.

Variety	Stalks treated (no.)	Stalks flowered (%)	Date of first flower emergence		
			Treated	Control	Treated - control (days)
CP 65-357 ⁺	8	0	-	11/18	-
L 62-96 ⁺	5	0	-	11/29	-
L 65-69 ⁺	7	0	-	11/29	-
US 66-56-9 ⁺	10	0	-	11/23	-
US 66-56-15 ⁺	12	0	-	11/23	-
Mandalay §	16	0	-	10/5	-
Okinawa # 2 §	44	0	-	9/16	-
SES 205 A §	26	0	-	9/30	-
SES 205 B §	27	0	-	9/24	-
SES 208 A §	30	0	-	9/30	-
SES 231 §	36	0	-	10/5	-
SES 278 §	48	68	8/25	9/11	-17
SES 351 §	48	83	9/7	9/15	- 8
Tainan (2n=96) §	16	100	11/18	9/24	+54
US 56-8-2 §	49	//	-	11/7	-

*Start of treatment, August 1, 1973; end of treatment, September 30, 1973.

⁺Commercial interspecific hybrids.

⁺US (breeding) hybrids, F₁L 60-25⁺ X US 56-15-8[§].

[§]*S. spontaneum* varieties.

//67% of the stalks tasseled, but flowers never opened.

By inducing parent canes to flower earlier or later by control of the photoperiod, we made 41 bi-parental crosses that would have been impossible under natural conditions (Table 4). In most of the 41 crosses, the interspecific commercial breeding canes were used as female parents and the US (breeding) canes and wild varieties were used as males; the latter generally produce a profusion of pollen under controlled conditions. New breeding lines were started with S. spontaneum varieties SES 50, SES 114, and Tainan (2n = 96) as possible sources of resistance to mosaic, cold, and borers Diatraea saccharalis (F.). Genealogies of 7 other new lines also were advanced as a direct result of photoperiod control (Table 4).

Table 4. Basic crosses and production of true seeds resulting from photoperiod induction, with reference to new line and generation, 1973 breeding season.

Basic parent	Species of basic parent	Generation	No. crosses	No. seeds
SES 50	<u>Saccharum spontaneum</u>	F ₁	1	280
SES 114	<u>S. spontaneum</u>	F ₁	3	8,080
Tainan (2n=96)	<u>S. spontaneum</u>	F ₁	1	15,840
US 65-102-1	<u>Erianthus arundinaceus</u> x (Retz.) Jesw.	F ₁	4	0*
Djatiroto	<u>S. spontaneum</u>	BC ₁	3	64
NG 57-208	<u>S. robustum</u> Brandes & Jesw. ex Grassl	BC ₁	3	8,260
SES 6	<u>S. spontaneum</u>	BC ₁	4	5,538
SES 146	<u>S. spontaneum</u>	BC ₁	1	5,600
US 56-15-8	<u>S. spontaneum</u>	BC ₂	17	31,673
Pasoeroean	<u>S. spontaneum</u>	BC ₃	1	266
Other +	-	-	3	2,059
Total	-	-	41	77,670

*Zero seed set was probably caused by an integeneric sterility factor.

Crosses were complex, including hybridization within and between new genetic stocks from different lines, different genera, and different generations; also these were seedlings from germination tests.

DISCUSSION

Control of the daylength is universally recognized as a tool to alter the flowering time of plants as a means to produce hybrids.

After nearly 4 decades of international study of photoperiodism as it applies to sugarcane breeding, factors affecting the phenomenon have been identified by research scientists. The technique has essentially become standard at most cane-breeding centers throughout the world.

Highly specialized photoperiod regimes have been developed that promote or retard the flowering of sugarcane to conform to the specific aims of breeders. The regimes vary to embrace short-, intermediate-, or long-day exposures, and these may be amended to include fixed, inclining, and declining daylengths or their combinations. Regardless of the treatment, photoperiod research is oriented toward synchronizing the flowering of diverse genetic material to produce superior crosses.

In the basic crossing program at Houma, photoperiod control was absolutely essential to produce the special crosses that would best broaden the genetic base of sugarcane, so we could breed future varieties with greater resistance to diseases and insect pests, higher yields of cane per acre, more sugar per ton of cane, improved cold tolerance, adaptability to mechanical harvesting, and longer and better ratooning capacity.

The initial success of the first photoperiod trials at Houma will lead to tests designed to involve a greater spread of unexplored germplasm in crosses basically designed to increase heterosis in breeding stocks intended for use in conventional breeding programs. Photoperiodism is being used to make crosses between selected clones of S. spontaneum and S. officinarum L. The newly evaluated S. spontaneum clones now available for crosses with S. officinarum are much more resistant to diseases and cold than those first used as nonrecurrent parents in India and Java, from which modern commercial canes are derived.

In the future, photoperiod treatment will undoubtedly expand basic breeding horizons at Houma and extend the capabilities of the crossing program. We hope to supply vital basic germ-plasm for the continuous improvement of commercial sugarcane varieties in the U.S.

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THE GENETIC BEHAVIOR OF RESISTANCE TO LODGING IN SUGARCANE:
METHODS OF CLASSIFICATION OF CLONAL PLOTS ^{1/}

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ABSTRACT

In 1972, research was begun on several aspects of the genetics of resistance to lodging. One of the phases has involved suitable methods of classifying small clonal plots for the degree or extent of lodging. One experiment included replicated plots of 8 varieties in the first and second stubble crops. A second experiment contained replicated clonal plots of 6 additional varieties in the plant cane crop. During both 1972 and 1973 the plots were classified for lodging by the conventional system based on 5 erectness classes that has been used by the USDA for many years. In this system of classification the 5 classes are differentiated on the basis of degree of erectness of the stalks. In the course of classifying the material during the 2 years, it became apparent that this conventional method did not provide satisfactory results. Several problems were encountered: a) The method did not differentiate adequately between varieties which were known to differ markedly in resistance to lodging and harvestability; b) most of the differentiation provided by the method was between degrees of erectness which were not related to an important extent with harvestability in so far as lodging is concerned; c) and, most important, the method did not permit recognition of differences between clonal plots in the percentages of stalks that were lodged severely. Due to the complications encountered with the conventional system, a different method of classification was devised and also used to classify the clonal plots in 1973. In the second classification system, a visual estimate was made for each plot of the percentage of stalks which were lodged, with lodged stalks defined as those which leaned from the vertical by at least 45°. This system of classification proved to be as rapid and simple as the conventional one and eliminated the problems encountered in use of the older method. In estimating the percentage of lodged stalks, it was observed that the lodging of virtually all severely-lodged stalks was due to failure of the root system to provide adequate support, or root lodging, rather than to bending of the stalks above the ground level.

INTRODUCTION

Erect stalk habit is considered a desirable agronomic characteristic by sugarcane growers in Louisiana. Lodging may cause a reduction in quality of juice and may have deleterious effects on both yield and harvestability.

De Sornay (2), in 1938, reported from Nauritius that although erectness was considered to be a desirable character, its heritability seemed to be low. Hebert and Henderson (3) concluded that selection for erectness in the initial single stool nurseries was relatively ineffective, although selection for erectness was practiced vigorously previous to these findings. They suggested that a large number of clonal plots be established yearly through a more liberal selection for erectness among single stools.

Skinner (7) determined physical lodging resistance of stalks by measuring the tension required to pull the stalks from the vertical through an angle of 16 or 20° with a spring balance. The physical lodging resistance measurements showed a positive association with natural lodging. He considered the character to be genetical and that selection for it would be as effective as selection for yield in replicated trials. Nagi and Mishra (6) said that a tendency for erectness or lodging seemed to be inherent in clones of Saccharum spontaneum L.

In 1960, Loupe (4) reported that selection for erectness in the stubble crop of single stools was effective. Morrill-Olavarrieta (5) concluded that lower minimum selection standards for stalk erectness should be practiced initially to allow inclusion of more genetically variable types.

Skinner (8) concluded that lodging regularly shows discontinuous expression but maintains an underlying continuous variability. Breaux (1) concluded that selection for erectness should

^{1/}The assistance of the American Sugar Cane League, members of the U. S. Sugarcane Laboratory, Houma, La., and the Louisiana Agricultural Experiment Station, Baton Rouge, La. made this research possible.

be conducted in the early test stages for clones that remain erect under normal conditions, but he found that this was not effective for sorting out varieties that would remain erect under conditions conducive to severe lodging.

A study of the genetic behavior of lodging in sugarcane was begun by the authors in 1972. The principle objectives of the investigation are: a) to develop and evaluate a new system for classifying clonal plots based on the percentage of stalks which are lodged; b) to determine the genetic behavior of lodging; c) to determine associations between stalk erectness and other important economic characters. This paper deals with the development and evaluation of a new system for classifying clonal plots based on the percentage of stalks which are lodged.

MATERIALS AND METHODS

The materials used in this study included replicated clonal plots of the parents of 8 biparental crosses. Eight parents involved in 4 biparental crosses - CP 52-68, CP 48-103, L 61-67, CP 62-258, CP 61-37, L 62-96, L 60-25, and CP 57-614 - were grown and classified in one experiment as first and second stubble clonal plots during the period of 1971-73. These 8 clones will be referred to as the Group I varieties. A second group of 6 varieties - CP 62-258, L 60-25, CP 66-346, CP 52-68, CP 65-357, and L 65-69 - were parents of 4 additional biparental crosses. These 6 varieties were grown and classified in a separate experiment only as plant cane in 1973 and will be referred to as the Group II varieties.

The materials were obtained from the U. S. Sugarcane Laboratory in Houma, Louisiana. In the fall of 1970, sufficient stalks of each Group I variety were harvested and used to establish 6 replicated clonal plots at the St. Gabriel branch of the La. Agric. Exp. Sta. Each replication consisted of a 10-foot plot. In 1972, the 6 Group II varieties were established in replicated plots in the same manner as for the Group I varieties.

The first classification of the Group I varieties for erectness was not made until the first stubble crop in 1972. For classifying the first stubble clonal plots, stalk erectness determinations in 1972 were based solely on a subjective rating scale used at the USDA station at Houma, as described and illustrated by Hebert and Henderson (3). The designations of the erectness classes are as follows: 1= very superior; 2= superior; 3= average; 4= inferior; and 5= very inferior.

In 1973, in addition to the conventional subjective rating scale, a different system was devised to classify the clonal plots. Instead of basing the classification on the degree to which the stalks deviated from the vertical - the conventional system used previously - in the new system a visual estimate was made for each plot of the percentage of stalks which were lodged, with lodged stalks defined as those which lean from the completely upright or vertical position by at least 45°. The new rating system was used in 1973 to classify each clonal plot of the second stubble crop of the Group I varieties and the plant cane crop of the Group II varieties.

RESULTS AND DISCUSSION

Classification of the varieties using the subjective rating scale based on 5 visual classes did not provide results which adequately differentiated certain varieties according to their known lodging habits.

Tables 1, 2, and 3 contain the results from classification of the Group I varieties in the first and second stubble crops and of the Group II varieties in the plant cane crop by the conventional classification system in 1972 and 1973, respectively. Note in Table 1 that there was some overlapping in erectness classes of the replications of certain varieties which are known to differ in their lodging habit. For example, only a small distinction is shown between the varieties CP 52-68 and CP 48-103, because of the considerable overlap of replications in Class 4. However, CP 52-68 is known as a very erect variety which presents few problems in harvesting, while CP 48-103 is known to be moderately susceptible to lodging.

Perhaps the most serious defect encountered in the conventional system was that the erectness classes were not closely related to the degree of harvestability of the plots. Although stalk erectness is only one of several factors which contribute to harvestability, we feel that it is safe to assume that an erect clone presents fewer problems than a lodged clone in harvesting regardless of other contributing factors. For example, although in 1973 three of the plots of the new variety CP 65-357 had stalks that leaned enough from the vertical to be placed in Class 4, considered to be undesirable, it was apparent in making the classification that few of the stalks were lodged sufficiently to cause difficulty or loss in mechanical harvesting.

Table 1. Frequency distributions in erectness classes based on the conventional system of classification for the 8 Group I varieties in the first stubble clonal plots.

Variety	No. of replications in each of the following erectness classes					Mean
	1	2	3	4	5	
CP 52-68		1	2	3		3.3
CP 48-103				5	1	4.2
L 61-67				1	5	4.8
CP 62-258					6	5.0
CP 61-37			3	1	2	3.8
L 62-96				1	5	4.8
L 60-25			1		5	4.7
CP 57-614		2	4			2.7

Table 2. Frequency distributions in erectness classes based on the conventional system of classification for the 8 Group I varieties in the second stubble clonal plots.

Variety	No. of replications in each for the following erectness classes				Mean
	1	2	3	4	
CP 52-68		2	3		2.6
CP 48-103			2	3	3.6
L 61-67			2	3	3.6
CP 62-258			3	2	3.4
CP 61-37				5	4.0
L 62-96				5	4.0
L 60-25				5	4.0
CP 57-614			4	1	3.2

Table 3. Frequency distributions in erectness classes based on the conventional system of classification for the 6 Group II varieties in the plant cane clonal plots.

Variety	No. of replications in each for the following erectness classes				Mean
	1	2	3	4	
CP 65-357			9	3	3.3
CP 62-258			2	4	3.7
L 60-25			2	4	3.7
CP 66-346		2	4		2.7
CP 52-68		2	4		2.7
L 65-69				12	4.0

The unreliability of the subjective rating scale to effectively differentiate certain varieties in respect to lodging makes it unsuitable for conclusions concerning the genetic behavior of resistance to lodging. Because of this unreliability of the subjective rating scale, the clonal plots of both the Group I and Group II varieties were reexamined, and it was noted that varieties known to be resistant to lodging, such as CP 52-68, CP 57-614, and CP 66-346, had very few stalks lodged sufficiently to cause problems and losses in harvesting, whereas varieties known to be susceptible to lodging, such as L 60-25 and CP 48-103, had a significant percentage of severely-lodged stalks.

Because of what the authors consider as defects in the conventional subjective classification system for lodging, it was considered desirable to devise a different classification

system that would more effectively distinguish between varieties in their tendency to lodge. In developing a new system the authors felt that certain features are required of a satisfactory system for classifying small clonal plots in respect to degree of lodging. The system must be able to differentiate adequately between varieties known to differ in both resistance to lodging and harvestability. The differentiation provided by the method must be between degrees of erectness which are not related to an important extent with harvestability. But, most importantly, the classification system must recognize differences between clonal plots in the percentage of severely lodged stalks, thereby giving an indication of harvesting difficulties.

In the new system, lodging was defined as a condition in which stalks were leaning enough to create problems in harvesting and lead to losses of cane. Only stalks which had an angle of inclination to the vertical of 45° or more were classified as lodged. In this system, stalks which leaned to only a limited degree and would not have created problems and losses in mechanical harvesting were not differentiated from those that remained completely upright. For each clonal plot of both the Group I and Group II varieties, a visual estimate was made of the percentage of the stalks which were lodged by the above definition, and this visual estimate was adopted as the new lodging classification.

The results of the reclassification of both the Group I and Group II varieties in 1973 based on the new lodging classification are presented in Tables 4 and 5, respectively. It is apparent that the new lodging classification provided more useful and accurate results since it effectively differentiated the varieties according to their known lodging behavior. Note in Table 4 that all 5 replications of CP 52-68 had no stalks leaning enough to affect harvestability adversely. On the other hand, 4 of the 5 replications of CP 48-103 had severely lodged stalks and most would have been difficult to harvest. Also, the experimental clone CP 57-614, which is known to possess resistance to lodging, performed well under the new system of classification. In contrast, L 60-25, with a record of susceptibility to lodging, had 50% or more of severely-lodged stalks in each replication.

Table 4. Frequency distributions for % lodged stalks of the 8 Group I varieties in the second stubble clonal plots.

Variety	No. of replications in each of the following % erectness classes											Mean
	0	10	20	30	40	50	60	70	80	90	100	
CP 52-68	5											00.0
CP 48-103	1	1	1		1	1						24.0
L 61-67	2			1	1	1						24.0
CP 62-258	3		1		1							12.0
CP 61-37					1		1	3				62.0
L 62-96					1	1	1	1			1	64.0
L 60-25						1			1	1	2	84.0
CP 57-614	3	1		1								8.0

Table 5. Frequency distributions for % lodged stalks of the 6 Group II varieties in the plant cane clonal plots.

Variety	No. of replications in each of the following % erectness classes											Mean
	0	10	20	30	40	50	60	70	80	90	100	
CP 65-357	9		1						1	1		15.8
CP 62-258	2				1	2				1		38.3
L 60-25	1	1			2	2						31.7
CP 66-346	6											00.0
CP 52-68	6											00.0
L 65-69						1	5	6				64.2

Data from classification of the Group II varieties (Table 5) also confirm the effectiveness of the new classification system. None of the stalks in plots of the lodging-resistant varieties CP 52-68 and CP 66-346 leaned to any serious degree, while all plots of susceptible L 65-69 contained 50% or more of severely-lodged stalks. The behavior of the new variety CP 65-357 is

somewhat uncertain. It is recognized as being resistant to lodging. However, in this experiment, although most of the plots were free of severely lodged stalks, in 2 of the 12 plots virtually all of the stalks were lodged severely.

It was our conclusion that the classification system based on estimates of the percentages of severely-lodged stalks is relatively simple to use, is applicable to small plots, and provides a reasonably reliable indication of the harvestability of clones in so far as lodging is concerned. As in other systems of classification, there is a strong environmental influence on lodging.

During the 1973 investigations, it was observed that, contrary to our prior opinion, lodging did not result from bending of the stalks at any point. In fact, in the region near the ground level severely lodged stalks of such susceptible varieties as L 65-69 and L 60-25 were as straight as the upright stalks of CP 52-68. Although the stalks of all varieties, both resistant and susceptible to lodging, showed some curvature near the ground level, this did not lead to enough bending to create problems in harvesting. Instead, the lodging that occurred in all varieties resulted from failure of the root system to maintain the stalks in an upright position. The type of lodging caused by the failure of the root system to support the stalks - the only type found in the 1973 studies - is common in corn and is generally designated as root lodging. We propose that the same term be used in sugarcane.

It was not possible to determine whether the root lodging resulted from damage to the root system or an inherent weakness in the root system. However, it was noted that lodged stalks could be pulled easily from the soil while erect stalks of the same variety could not.

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COMPARISON OF 2-STAGE SELECTION SCHEMES IN SUGARCANE

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ABSTRACT

A 6-year selection study was conducted to determine the efficiency of the 4 possible 2-stage selection schemes in a population of 376 sugarcane clones. These clones were grown in plant and ratoon crops of seedlings, 1.2-m clonal plots, and 4.6-m clonal plots. For cost, selection efficiency was greater for stalk number in the plant crop of seedlings than in the ratoon crop of seedlings. Selection for stalk diameter was more efficient in the plant crops of seedlings and 1.2-m clonal plots. Cost efficiency for brix selection did not differ consistently in plant or ratoon crops of seedlings and 1.2-m clonal plots. We considered total cost units as 100% for selection of stalk number, stalk diameter, and brix with the 2-stage scheme of plant crop seedlings/plant crop 1.2-m clonal plots. The total cost units were 100.6% with the 2-stage scheme of plant crop seedlings/ratoon crop 1.2-m clonal plots. However, total cost units were 112.6% with the 2-stage scheme of ratoon crop seedlings/plant crop 1.2-m clonal plots. Total cost units were 109% with the 2-stage scheme of ratoon crop seedlings/ratoon crop 1.2-m clonal plots.

Gain in stalk number and stalk diameter was 8 or 9% from selection in seedling crops and ranged from 4 to 7% for selection in the subsequent 1.2-m clonal plots. Total gain ranged from 13 to 15% for the 2-stage selection schemes. Total gain was about half as much for brix as for stalk number and stalk diameter and was 4% from selection in seedling crops and 2 to 4% from selection in 1.2-m clonal plots.

INTRODUCTION

Several years are required to collect enough data for comparison of selection schemes in sugarcane. For this reason, little information is available on this important subject. Skinner (7) devised a method and compared several selection schemes, but he emphasized selection rates in the original seedling population (plant-crop seedlings). Other studies (1, 3, 5) were conducted on seedlings of the plant-crop, ratoon-crop, or both, where performance was judged in the first vegetative stage, usually in plots about 1.5 m long. These studies did not permit comparison of selection schemes in the plant and ratoon crops of different stages of selection.

We (4) determined optimum selection rates for land-use and cost efficiency from data on a population of 376 sugarcane clones in the plant and ratoon crops of seedlings, 1.2-m clonal plots, and 4.6-m clonal plots. Three characters, stalk number, stalk diameter, and brix, were considered. Stalk number and stalk diameter are the major components of cane yield (2), and along with brix, they are the major components of sugar per hectare. In this paper, we compare all possible combinations of 2-stage selection schemes for stalk number, stalk diameter, and brix in plant and ratoon crops of seedlings and 1.2-m clonal plots. We used the optimum selection rates from the previous paper (4) and judged quality of clones on average performance in plant and ratoon crops of 4.6-m clonal plots.

MATERIALS AND METHODS

We planted sexual seed of 4 sugarcane crosses in sterilized muck soil in January 1967. These crosses (cross 1 = CP 59-50 x CP 57-603, cross 2 = CP 62-374 x CP 57-603, cross 3 = US 59-16-1 x CP 57-614, and cross 4 = CP 62-374 x CP 57-614) were selected to show a range of character expression. The resultant seedlings were kept in the greenhouse until mid-April and then transplanted to the field. Each plot consisted of 2 rows, 1.5 m apart, with 50 full-sib seedlings spaced at 0.6-m intervals within the rows. The experimental design was a randomized block with 3 replications. Stalk number, stalk diameter, and brix were recorded in the fall of 1967 for the plant crop of seedlings and in the fall of 1968 for the first ratoon crop of seedlings. Beginning in the fall of 1968, data were collected only on replications 1 and 2.

Single-bud stalk segments from one stalk of each seedling were planted in flats in the greenhouse after data were collected in the fall of 1968. Single-row clonal plots of each seedling were established by transplantation to the field in January 1969. Each plot contained 4 plants 0.3 m apart; plots were in rows 1.5 m apart. Data were taken in November 1969 on the plant crop and in November 1970 on the first ratoon crop. Seed cane was obtained from the second ratoon crop in September 1971 to establish 2-row plots 4.6 m long. Data from this planting were recorded in October 1972 on the plant crop and in October 1973 on the first ratoon crop.

Stalk number of individual plants was determined in the seedling and 1.2-m clonal plots. All data on stalk number are presented as stalks per meter of row, because individual plants could not be identified in the 2-row plots 4.6 m long where two lines of seedcane were planted to establish plots.

Stalk diameter (in millimeters) was obtained as an average of 5 stalks in each of the 6 crops. When fewer than 5 stalks were present, all stalks were measured.

Brix was determined with a hand refractometer in the first 4 crops and with a brix hydrometer in the last 2 crops.

Culling levels for each of the 3 characters, stalk number, stalk diameter, and brix, were established at $\bar{X}$ and $\bar{X} + 0.25s$ (where "s" was the standard deviation) to provide 50 and 40% selection rates previously identified as optimal (4). The 4 possible 2-stage selection schemes were applied for each character independently in the plant and first ratoon crops of seedlings and 1.2-m clonal plots.

We used a modification of Skinner's (7) method to determine the number of acceptable clones per hectare-year and the number of cost units per acceptable clone for each of the 4 two-stage selection schemes for each character. Acceptability was judged on average performance ($\geq \bar{X} + 0.5s$) in plant and ratoon crops of two-row plots 4.6 m long. Hectare-years were determined for selection as follows:

- (i) Plant-crop seedlings = A,
where $A = \frac{\text{no. of seedlings} \times \text{m}^2/\text{seedling} \times 2 \text{ yr}}{\text{m}^2/\text{ha}}$
- (ii) First ratoon-crop seedlings = 1.5 A
- (iii) Plant-crop 1.2-m plots = B,
where $B = \frac{\text{no. of 1.2-m clonal plots} \times \text{m}^2/\text{plot} \times 2 \text{ yr}}{\text{m}^2/\text{ha}}$
- (iv) First ratoon crop 1.2-m clonal plots = 1.5 B
- (v) 4.6-m clonal plots = C
where $C = \frac{\text{no. of 4.6-m plots} \times \text{m}^2/\text{plot} \times 3 \text{ yr}}{\text{m}^2/\text{ha}}$

The number of seedlings in A = 376; the number of 1.2-m plots in B = number of selections from seedlings; the number of 4.6-m clonal plots in C = number of selection from 1.2-m clonal plots.

The number of hectare-years was obtained from addition of the 2 appropriate factors (i to iv) for the particular 2-stage selection scheme and the factor (v) for the 4.6-m clonal plots. The number of acceptable clones per hectare-year was then obtained from division of the number of acceptable clones by the number of hectare-years. When we selected for brix, we calculated cost units assuming that plant-crop costs, compared to ratoon-crop and fallow costs, were 6, 2, and 1.5 times as much for seedlings, 1.2-m plots, and 4.6-m plots, respectively. Costs were reduced 10% in the seedling crops and 5% in the 1.2-m clonal crops when we selected for stalk number and stalk diameter, because selection for these characters cost less than does that for brix. Costs for the plant crop of seedlings included land rental, raising of seedlings, transplanting, maintenance, and selection; additional costs of the ratoon crop and the fallow year included only land rental and maintenance. Costs in the plant crop of 1.2-m and 4.6-m clonal plots included land rental, planting, maintenance, and selection. A fallow year followed each crop cycle.

Cost units for brix were calculated as follows:

- (i) Plant-crop seedlings = 3.50 A x 1,000
- (ii) First ratoon-crop seedlings = 4.00 A x 1,000
- (iii) Plant-crop 1.2-m clonal plots = 1.50 B x 1,000
- (iv) First ratoon-crop 1.2-m clonal plots = 2.00 B x 1,000
- (v) 4.6-m clonal plots = 1.17 C x 1,000

The coefficients 3.20, 3.70, 1.45, and 1.95 were substituted in equations i, ii, iii, and iv, respectively, when we selected for stalk number and stalk diameter. Total cost units for each two-stage selection scheme were obtained from addition of cost units in i or ii, iii or iv, and v.

Total cost units divided by number of acceptable clones equalled cost units per acceptable clone for each 2-stage selection scheme.

Gain from selection for each population was calculated on average performance of selected populations in plant and ratoon crops of 4.6-m clonal plots. This method eliminated year-to-year variation and therefore showed true gain.

RESULTS AND DISCUSSION

Table 1 shows the means and standard deviations for the 3 characters, stalk number, stalk diameter, and brix, in the first 4 crops and the average of the 2 crops of 4.6-m clonal plots. Stalk number per meter of row was smaller in the plant crop of seedlings than in the other crops. Stalk number and stalk diameter varied more in ratoon crops than in plant crops of seedlings and 1.2-m clonal plots. In contrast to stalk number, stalk diameter was smaller in ratoon crops than in plant crops. Brix measurements, obtained early in the season, showed that the ratoon crops were more mature than the plant crops.

Table 1. The means and standard deviations for stalk number (per meter), stalk diameter (in millimeters), and brix in a population of 376 sugarcane clones in 6 crops.

Crop	Stalk number		Stalk diameter		Brix	
	X	S	X	S	X	S
Plant-crop seedlings	13.1	5.84	23.76	2.65	12.14	1.80
Ratoon-crop seedlings	16.9	10.23	22.36	3.02	16.10	2.12
Plant-crop 1.2-m clonal plots	19.5	4.93	25.86	2.91	15.32	2.16
Ratoon-crop 1.2-m clonal plots	19.8	6.82	25.04	3.10	18.25	1.62
Average 2 crops 4.6-m clonal plots*	15.3	3.02	27.70	2.70	16.16	1.38

*The average performance of the plant and first ratoon crops in 2-row plots 4.6 long.

Table 2 shows the data for the 4 possible 2-stage selection schemes in the plant and ratoon crops of seedlings and 1.2-m clonal plots for stalk number, stalk diameter, and brix. Selection rates, previously identified as optimum (4), were 40% for all characters in the seedling crops and 50% for all characters in the plant crop of 1.2-m clonal plots. They were 50, 40, and 40% for stalk number, stalk diameter, and brix, respectively, in the first ratoon crop of 1.2-m clonal plots. Culling levels were applied to give the above selection rates, with the assumption that the populations were normally distributed. Deviations from normality in these populations caused the differences between expected and actual selection rates.

Total gain from selection for stalk number was about equal among the 4 two-stage selection schemes and ranged from 13 to 15%. Selection in the seedling crops resulted in more gain than selection in the 1.2-m clonal plots. The number of acceptable clones per hectare-year, a measure of land-use efficiency, was greater for the 2 schemes in which seedlings were selected in the first ratoon crop. Selection for stalk number in the plant and ratoon crops of 1.2-m clonal plots produced about the same number of acceptable clones per hectare-year.

Only differences larger than 10% were considered significant among cost units per acceptable clone. The 2 schemes in which seedlings were selected for stalk number in the plant crop were more efficient than the 2 schemes in which seedlings were selected in the first ratoon crop. Selection in the ratoon crop of the 1.2-m clonal plots tended to be more efficient than selection in the plant crop, but these differences were less than 10%.

As with stalk number, total gain from selection for stalk diameter was about equal among the 4 two-stage selection schemes and ranged from 13 to 15%. Gain was greater from selection in seedling crops than from selection in 1.2-m clonal plots.

The 2-stage scheme for selection of stalk diameter in the plant crops of seedlings and 1.2-m clonal plots tended to be more efficient for land use than the other 3 schemes, but, again, these differences were less than 10%. Selection was significantly better for land use in the plant crop than in the ratoon crop of the 1.2-m clonal plots. For cost, selection was more efficient in the plant crop than in the ratoon crop of seedlings. The least efficient scheme was

Table 2. Comparison of all possible two-stage selection schemes for stalk number, stalk diameter, and Brix in a population of 376 sugarcane clones in plant and first ratoon crops of seedlings and 1.2-m clonal plots.

Selection scheme	Evaluation in							Efficiency	
	1.2-m plots			4.6-m plots			Total gain from sel. (%)	Clones/ha-yr	Cost units/accept. clone
	No. sel. in seedlings	Sel.* rate(%)	Gain from sel. (%)	No. sel. in 1.2-m plots	Sel.* rate(%)	Gain from sel. (%)			
					Stalk number				
PS-Pl.2m**	151	40.2	9	76	50.3	4	19	13	37.4
PS-Rl.2m	151	40.2	9	62	41.1	6	18	15	38.7
RS-Pl.2m	146	38.8	8	69	47.3	5	16	13	31.7
RS-Rl.2m	146	38.8	8	60	41.1	6	16	14	32.8
					Stalk diameter				
PS-Pl.2m	161	42.8	8	74	46.0	5	24	13	47.9
PS-Rl.2m	161	42.8	8	60	37.3	7	20	15	43.4
RS-Pl.2m	145	38.6	9	72	49.7	4	23	13	44.2
RS-Rl.2m	145	38.6	9	53	36.6	6	17	15	37.6
					Brix				
PS-Pl.2m	156	41.5	4	77	49.4	2	20	6	38.9
PS-Rl.2m	156	41.5	4	65	41.7	3	17	7	35.2
RS-Pl.2m	168	44.7	4	80	47.6	2	20	6	35.2
RS-Rl.2m	168	44.7	4	55	32.7	4	18	8	37.9

* Optimum selection rates were 40% for all characters in PS and RS, 50% for all characters in Pl.2m and for stalk number in Rl.2m, and 40% for stalk diameter and Brix in Rl.2m. Deviations from normality in the populations caused the differences between the selection rates shown and the optimum rates.

** PS = plant-crop seedlings; Pl.2m=plant crop of 1.2-m clonal plots.
RS = ratoon crop of seedlings; Rl.2m = ratoon crop of 1.2-m clonal plots.

selection in the ratoon crop of seedlings, followed by selection in the ratoon crop of 1.2-m clonal plots.

Total gain from selection for brix was about half that for the other 2 characters and ranged from 6 to 8%. Land-use and cost efficiency did not consistently differ between plant and ratoon-crop selection in seedlings and 1.2-m clonal plots. These data show that if seedlings are selected in the ratoon crop, then selection in 1.2-m clonal plots is also more efficient in the ratoon crop.

Total cost units were calculated for stalk number, stalk diameter, and brix as a percentage of the 2-stage selection scheme of plant-crop seedlings followed by plant-crop 1.2-m clonal plots. These cost units were 100.6% for the 2-stage scheme of plant-crop seedlings followed by ratoon crop 1.2-m clonal plots, 112.6% for the 2-stage scheme of ratoon-crop seedlings followed by plant-crop 1.2-m clonal plots, and 109.0% for the 2-stage scheme of ratoon-crop seedlings followed by ratoon-crop 1.2-m clonal plots.

Simultaneous selection for the 3 characters in the plant crop of seedlings was more efficient than selection in the ratoon crop of seedlings. There was little difference in efficiency between selection in the 2 crops of the 1.2-m clonal plots.

Figures 1-3 show the characteristics of the populations selected for stalk number, stalk diameter, and brix when we applied the 2-stage selection scheme of plant-crop seedlings followed by plant-crop 1.2-m clonal plots. The means of populations selected for stalk number were increased from 15.3 to 16.7 and then to 17.3. That the population selected from the 1.2-m clonal plots was still widely dispersed showed that repeatability of stalk number was low, as previously shown (6). However, clones with low stalk number/meter of row appeared to be eliminated with greater frequency than those with high stalk number/meter of row.

The characteristics of the populations selected for stalk diameter reflect the higher repeatability of this character compared to stalk number. Most of the clones with small diameter were eliminated. The mean of the selected population increased with each successive selection stage.

The distributions show that repeatability was not as high for brix as for stalk diameter, because the dispersion was greater for brix than for stalk diameter, and more of the high-brix clones were discarded during the 2-stage selection process. The distributions of populations that were selected for brix were more nearly normal than the distribution for the parent (total) population, which was skewed to the left. Although large numbers of low-brix clones were eliminated during the 2-stage selection process, the means of the selected populations were not increased greatly. This small increase resulted in relatively low gain from selection for brix.

These data show that, at least under conditions of these experiments, selection for stalk number, stalk diameter, and brix is more efficient in the plant crop than in the ratoon crop of seedlings and about equal in the 2 crops of 1.2-m clonal plots.

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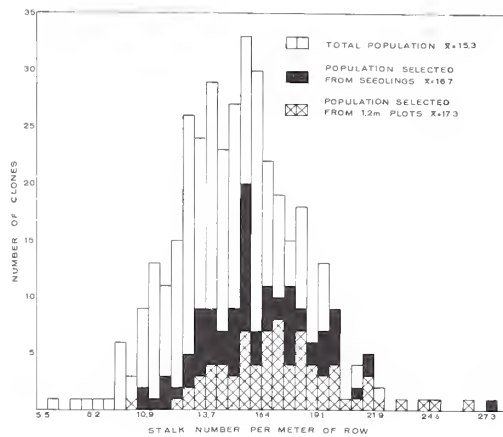


Fig. 1. Distribution of clones for stalk number per meter of row for parent population (376 clones), population selected from plant crop seedlings, and population reselected from those clones in the plant crop of 1.2-m plots, where stalk number was determined on average performance in plant and first ratoon crops of 4.6-m clonal plots.

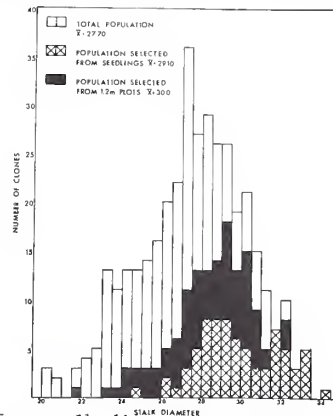


Fig. 2. Distribution of clones for stalk diameter for parent population (376 clones), population selected from plant crop seedlings, and population reselected from those clones in the plant crop of 1.2-m clonal plots, where stalk diameter was determined on average performance in plant and first ratoon crops of 4.6-m clonal plots.

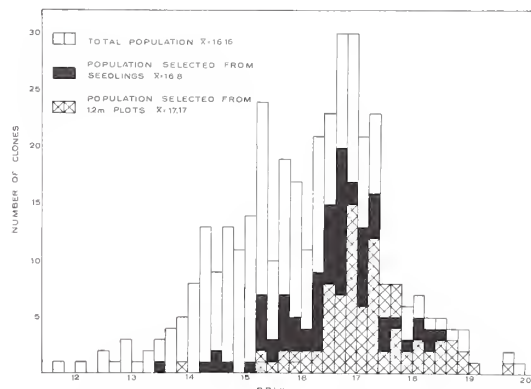


Fig. 3. Distribution of clones for brix for parent population (376 clones), population selected from plant crop seedlings, and population reselected from those clones in the plant crop of 1.2-m clonal plots, where brix was determined on average performance in plant and first ratoon crops of 4.6-m clonal plots.

RADIOSENSITIVITY AND SELECTION FOR MOSAIC-RESISTANT
VARIANTS IN SUGARCANE 1/

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ABSTRACT

The radiosensitivity of ungerminated buds of 9 mosaic-susceptible sugarcane varieties to gamma (^{60}Co) irradiation was measured. Normal plants predominated in all 9 varieties in a greenhouse test after 2.5 Kr and 5.0 Kr of irradiation and in 2 varieties after 7.5 Kr of irradiation, but fewer than 10% survived as normal plants in most of the 9 varieties after 10.0 Kr of irradiation. In August 1972, more than 500 subclones of the variety CP 65-357 from irradiated single-eye cuttings were planted to 6-ft line trials. They were alternated with 6-ft plots of NCo 310, heavily infected with mosaic, in the Teche area. Fifty-six of these clones remained free of mosaic and were increased in the fall of 1973. However, all 56 were infected with mosaic to some degree in the spring of 1974, indicating that most had been escapes. One of the clones, though not immune, appeared to be more resistant to mosaic than was CP 65-357 in the greenhouse and the field.

INTRODUCTION

Mutation is induced in vegetatively propagated plants primarily to change one or a few characters of an outstanding cultivar without altering the remaining genotype. Although mutation breeding of sugarcane (*Saccharum* sp.) is no substitute for a conventional breeding program, mutation breeding may be considered primarily as a possible means to perfect the leading products of conventional breeding.

The successful recovery of variance after irradiation of dormant sugarcane buds was recently reported from India, Hawaii, and Barbados (1, 3, 4). Rao, Srinivason, and Alexander (1) irradiated Co 449 and selected a subclone resistant to strain D of red rot, to which Co 449 is highly susceptible. Urata (3) reported that a subclone of H 52-263 that was decidedly more tolerant to a herbicide was identified in irradiated material of that clone. Walker and Sisodia (4) and Rao (2) isolated nonflowering variants from several free-flowering Barbados varieties with irradiation.

The most recently released variety in Louisiana, CP 65-357, and many promising unreleased varieties are susceptible to strain H of sugarcane mosaic. Otherwise, CP 65-357 is an exceptional clone combining high cane tonnage, high sucrose, erectness, and cold tolerance. These reports and the desire to increase the resistance of CP 65-357 to mosaic have stimulated irradiation breeding at the Houma Laboratory.

MATERIALS AND METHODS

In August 1971, ungerminated buds of mosaic-susceptible sugarcane varieties were irradiated at the Nuclear Science Center, Louisiana State University, Baton Rouge, Louisiana. Irradiation with a ^{60}Co source was done in a cylinder about 12 in. in diameter and 21 in. long. About 60 to 75, 3- or 4-eye seed pieces were placed in the chamber at one time.

Radiosensitivity: An experiment was conducted to determine the radiosensitivity of 9 mosaic-susceptible sugarcane varieties: CP 52-68, CP 65-357, CP 67-411, CP 67-413, CP 69-302, CP 69-380, L 60-25, L 62-96, and NCo 310. About 250 to 300 eyes of each variety were irradiated with gamma rays at each of 4 dosage rates: 2.5, 5.0, 7.5, and 10.0 Kr.

After irradiation, the 3- to 4-eye seed pieces were cut into single-eye pieces and incubated at 95 F. The radiosensitivity of each variety was measured in terms of percent germination after 4 days of incubation. Unirradiated controls were included.

A 4-replicate simple factorial experiment for the 9 varieties x 5 dosage rates was transplanted to sterile field soil in 3-in. peat pots in the greenhouse. Each replication had 20 single-eye seed pieces for each treatment of each variety.

1/ Research at this location is done in cooperation with the Louisiana Agricultural Experiment Station.

The radiosensitivity of each variety was again measured in terms of percentage of normal plants 5 weeks after transplanting. An analysis of variance was conducted to test significance of differences among varieties, dosage rates, and the variety x dosage rate interaction.

Selection and evaluation of mosaic-resistant subclones: An additional 5000 buds of CP 65-357 were treated with gamma rays at a dose of 5.0 Kr as previously described. Seed cane for the experiment was obtained from Florida, which because of quarantine regulations, necessitated a short, hot water treatment before irradiation in Louisiana.

The hot water treatment was very severe and after irradiation only 1300 eyes survived. The incubated, pregerminated, single-eye pieces were transplanted to 3-in. peat pots, inoculated with mosaic, and grown in the greenhouse over the winter of 1971-72.

In April 1972, about 900 subclones were established in the field at Houma in single stools. Stools remaining 100% infected with mosaic were destroyed in late June. In August, 2 stalks were cut from each stool that was free of mosaic symptoms. Each subclone was established in a 6-ft, single-row plot at the plantation of A. V. Allain & Sons, Jeanerette, Louisiana, to expose them to heavy mosaic infestation in the field; 657 subclones were transferred. Each subclone was bordered on 4 sides by mosaic-infected NCo 310.

Mosaic-free subclones were carefully identified throughout the spring and early summer of 1973. In August, 56 subclones, still free of mosaic, were replanted to a 3-replicate field-spread test (6-ft, single-row plots) at Allain Farms. A greenhouse test was also established at the Houma Laboratory to determine the mosaic susceptibility of these subclones to artificial inoculation. Two replications of 7 plants each were used for the greenhouse test. An unirradiated CP 65-357 control was included in the field and greenhouse tests.

The percentage of mosaic-infected plants in the greenhouse test and the percentage of mosaic-infected shoots in the field test were recorded. Analyses of variance were conducted for the tests to determine if any of the subclones differed significantly from untreated CP 65-357 in resistance to sugarcane mosaic.

RESULTS AND DISCUSSION

Radiosensitivity: Gamma irradiation had no significant effect on germination of eyes of any of the 9 varieties tested (Table 1). Surprisingly, even 7.5 and 10.0 Kr of irradiation, which drastically affected later plant development, did not depress initial bud germination.

Table 1. Percent germination of gamma-irradiated buds of 9 sugarcane varieties after 4 days incubation.

Variety	Irradiation (Kr)					Av.
	0.0	2.5	5.0	7.5	10.0	
CP 52-68	100	98	96	100	98	98
CP 65-357	100	96	97	98	98	98
CP 67-411	95	100	95	99	91	96
CP 67-413	98	98	96	100	93	97
CP 69-302	92	90	96	94	90	92
CP 69-380	95	71	81	85	94	85
L 60-25	96	93	94	100	98	96
L 62-96	91	85	96	99	100	94
NCo 310	93	94	99	96	98	96
Average	96	92	94	97	96	-

Differences among varieties, dosage rates, and the variety x dosage rate interaction were highly significant when the effects of irradiation were measured in terms of percentage of normal plants 5 weeks after irradiation (Table 2). Plant height was generally reduced for most varieties as dosage rate increased. Many plants from buds treated at the higher rates died shortly after emergence. Most of the plants that either died or were discarded were severely stunted, with short, thick, dark-green, leatherly leaves.

Table 2. Percentage of normal plants of 9 sugarcane varieties 5 weeks after gamma irradiation of buds.

Variety	Irradiation (Kr)				
	0.0	2.5	5.0	7.5	10.0
CP 52-68	100 a ^{1/}	96 ab	80 b	15 c	7 c
CP 65-357	98 ab	100 a	82 b	18 c	6 c
CP 67-411	95 ab	98 a	79 b	25 c	22 c
CP 67-413	98 a	83 a	87 a	85 a	20 b
CP 69-302	92 a	95 a	90 a	51 b	7 c
CP 69-380	94 a	91 a	61 b	21 c	14 c
L 60-25	100 a	93 ab	81 b	26 c	21 c
L 62-96	98 a	83 a	91 a	67 b	2 c
NCo 310	86 ab	92 a	71 b	18 c	10 c
Average	96	92	80	36	12

^{1/}Treatments followed by different letters within rows are significantly different at the 5% level of probability using Duncan's Multiple Range Test.

The 2.5 Kr dosage rate had little effect on any of the 9 varieties (Table 2). After the 5.0 Kr of irradiation, only 3 varieties, CP 52-68, CP 69-380, and L 60-25, had significantly fewer normal plants than the control. However, CP 52-68 and L 60-25 still had over 80% normal plants and CP 69-380 over 60% normal plants. With 7.5 Kr of irradiation, over 50% of the plants died or were grossly abnormal in all but 3 of the 9 varieties. CP 67-413 showed unusual tolerance to 7.5 Kr of irradiation, with 85% normal plants. All of the varieties were very adversely affected by 10.0 Kr of irradiation.

The results showed that variety response to irradiation is unpredictable but that dosage rates appreciably higher than 5.0 Kr are very damaging to ungerminated buds of most Louisiana sugarcane varieties. If large-scale selection of irradiated canes is planned, rates higher than 5.0 Kr should not be used, unless a variety is known to tolerate them or does not respond at all to dosages of 5.0 Kr or less.

Mosaic reaction of selected subclones: The 56 selected subclones of CP 65-357 differed significantly in mosaic susceptibility in both the greenhouse and field tests.

In the greenhouse, 85% of the plants of the unirradiated CP 65-357 control was infected when artificially inoculated with mosaic. In the 56 subclones, mosaic infection ranged from 14% to 100% (Fig. 1). The experimental error was large, and only one subclone #28, had significantly less mosaic than the unirradiated control.

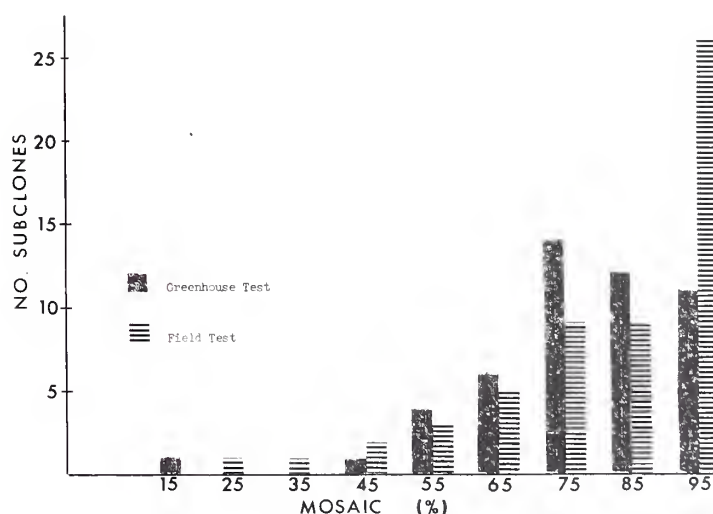


Fig. 1. Mosaic infection in 56 subclones of CP 65-357 in the greenhouse and in the field.

In the field, 100% of the shoots of unirradiated CP 65-357 became naturally infected with mosaic. In the same 56 subclones, field infection ranged from 25 to 100% (Fig. 1). Subclone #28 was again the most resistant one (25%). Five other subclones had significantly less mosaic than the control.

Most of the 56 selected subclones were undoubtedly escapes from previous tests. None was immune to mosaic, but a few, particularly subclone #28, might be useful variants with a higher degree of resistance than the parent clone. Resistant and moderately resistant varieties in which mosaic can be commercially controlled often become infected to some degree in small-plot exposure trials. The practical value of the subclones will depend on their stability and behavior in future trials.

The apparently mosaic-resistant subclones closely resemble CP 65-357. Subclone #28 sheds its leaves sooner than CP 65-357 and, therefore, appears to have a darker green color of the stalk. It does not appear to differ greatly from CP 65-357 in vigor; however, preliminary analyses indicate that its juice quality may be inferior. Its yield characteristics will be compared with those of CP 65-357 beginning in 1975.

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BACTERIUM ASSOCIATED WITH RATOON STUNTING DISEASE

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ABSTRACT

Results of light microscopy, ultrafiltration, electron microscopy, and infectivity tests indicate the association of a small, rod-shaped bacterium with ratoon stunting disease. Small, gram-positive bacteria have been isolated from diseased plants. Studies are in progress on the relationship of these organisms to the disease. The use of serology as a diagnostic technique for the disease is being investigated.

FIELD-PLANTING OF SUGARCANE HOT-WATER TREATED FOR SUGARCANE
MOSAIC AND RATOON STUNTING DISEASE CONTROL

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ABSTRACT

The tolerance to heat required for disease control can be increased by exposing cuttings or whole stalks of sugarcane (Saccharum hybrids) to a series of hot-water treatments at daily intervals. Most infected buds treated for 20 min each on 3 successive days at 52 (pretreatment), 57.3, and 57.3 C have been cured of sugarcane mosaic and ratoon stunting disease, singly or together. Longer treatments are required for certain combinations of mosaic virus strains and cane varieties. Some factors favor the survival of buds of heat-treated, 6- to 9-month-old stalks: (a) living sheaths left to cover the buds; (b) stalks harvested 1 to 5 days before beginning of treatment; (c) avoidance of extremes of temperature and humidity before and between treatments; (d) prompt planting after completion of the treatment series; and (e) for heat-sensitive varieties, adjustment of the length of the pretreatment. Stubble cane appears to survive treatment better than plant cane. However, shoots from cured buds can become reinfected by mosaic virus. If a diseased shoot from an uncured bud is present on the same seedcane piece, the virus may spread through the seedcane after planting. To reduce the chance of reinfection, immature nodes, which generally survive treatment uncured, should be discarded. Also, shorter rather than longer cuttings should be planted.

GREENHOUSE CONTROL OF THREE SUGARCANE SEEDPIECE PATHOGENS
WITH THIOPHANATE METHYL ¹/

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ABSTRACT

Only 10% of one-node seedpieces germinated when potted in soils infested with red rot, black rot, and pineapple disease pathogens. More than 80% of similar seedpieces germinated after immersion in 0.7% (a.i.) thiophanate methyl (TPM) suspension for 10 min and planting in infested soil. More than 75% of one-node seedpieces treated with TPM and immersed in spore suspensions of the 3 pathogens together or alone germinated after these were planted in steamed soil, but less than 40% of untreated seedpieces germinated. Whole stalks were harvested from plants growing in pots that had been drenched once with 0.28% (a.i.) TPM 2, 4, and 6 weeks before harvest. These were inoculated separately with the 3 pathogens, which did not spread from the inoculation sites. However, the pathogens spread in untreated stalks. More than 90% of the one-node seedpieces obtained from plants in drenched pots germinated, whereas less than 20% of those from untreated pots germinated in potted soils infested with the 3 pathogens together. The results from greenhouse experiments show that TPM can increase the germination of seedpieces by protecting against the 3 pathogens.

INTRODUCTION

Ceratocystis adiposa (Butl.) C. Moreau (black rot pathogen), *C. paradoxa* (Dade) C. Moreau (pineapple disease pathogen), and *Collectotrichum falcatum* Went (imperfect state of *Physalospora tucumanensis* Speg., red rot pathogen) can seriously affect the germination of sugarcane seedpieces and cause poor stands in fields (2). Dip treatment of seedpieces with the systemic fungicides benomyl (4) or thiophanate methyl (dimethyl 4, 4'-o-phenylenebis [3-thioallophanate]) (TPM) (6) is used to protect the seedpieces against pineapple disease. The application of fungicide before covering to control soil-borne diseases of seedpieces has succeeded with benomyl in foam under field conditions (5). The incidence of red rot in seedpieces was greatly reduced and yield of sugarcane was increased by air-pressure injection of benomyl into short seedpieces (3). The control of red rot and black rot in sugarcane seedpieces with TPM has not been studied previously, and the concept of protecting seedpieces from rot organisms by treating the growing plants with a systemic fungicide before cutting the seedpieces has not been tested.

These studies were undertaken to test this concept as well as to determine the efficacy of TPM against all 3 seedpiece pathogens.

MATERIALS AND METHODS

By standard culture methods, *Ceratocystis adiposa* and *C. paradoxa* were isolated on potato dextrose agar (PDA) from the ungerminated seedpieces of several sugarcane varieties, and *Collectotrichum falcatum* was isolated on oatmeal agar (OA) from the sugarcane leaf midrib of the variety L 62-96. Pathogenicity of all 3 was ascertained on stalks of varieties CP 44-101 and L 62-96. Inocula were prepared from PDA or OA cultures that had been incubated at 25 or 30 C for 1 to 2 weeks. Spores were suspended in distilled water, the suspensions were filtered through cheesecloth, and the spore concentration was standardized by dilution. For a mixture of spore suspensions, we mixed equal portions of the standardized spore suspensions of each of the 3 pathogens.

Soils infested with 3 pathogens together were prepared by mixing soil with ground stalk tissues in a concrete mixer for 15 min. The ground stalk tissue of the 3 pathogens was prepared from equal weights of stalks that had been inoculated separately with each pathogen and incubated at room temperature (22 C) for more than 3 weeks. Soils mixed with ground, uninoculated stalks were used as control. Each 23-cm pot contained 5,443 g soil and 136 g ground stalks.

TPM suspension was freshly prepared by suspending 1 g TPM (70% wettable powder, Pennwalt) in 5 ml technical-grade acetone and then diluting the suspension with Plyac-tap water (0.03:100 v/v) to a final concentration of 0.7% (a.i.) or 0.28% (a.i.). The Plyac-tap water had been adjusted to pH 4 with 1 N HCl. Unless otherwise stated, the 0.7% TPM suspension was used for dipping seedpieces (500 ml/10 seedpieces) and the 0.28% suspension for frenching potted plants (250 ml/pot). Tap water was used as a check of fungicide treatments, and distilled water was

¹/Research at this location is done in cooperation with the Louisiana Agricultural Experiment Station.

used as a check of spore suspension in all experiments. At the end of the experiment, the pathogens were reisolated on PDA or OA from the inoculated and uninoculated seedpieces or stalks by standard culture method.

The following types of inoculation were tested:

A. Dipping one-node seedpieces in TPM suspension before planting. As seedpieces of 5 varieties (Table 1) were immersed in TPM suspension for 10 min, air-dried, immersed for 5 min in the spore suspensions singly or in mixture, and then dried again. Then the seedpieces were planted in pots containing steamed soil. One seedpiece was planted in each 15-cm pot. The pots were kept in a dark room (15-21 C) or on a greenhouse bench (18-36 C). Germination of seedpieces was recorded 4 and 6 weeks after planting.

In a second experiment, one-node seedpieces of varieties CP 61-37 and L 62-96 were immersed in the TPM suspension and planted in potted soils infested with a mixture of the 3 pathogens. The pots were kept on the greenhouse floor (15-26 C). Germination of seedpieces was recorded 4 weeks after planting.

In another experiment, one-node seedpieces of CP 61-37 and L 62-96 were dipped in 0.21% (a.i.) TPM suspension and then in mixed spore suspensions of the 3 pathogens and then planted in steamed and nonsteamed soil. Each treatment had 9 one-node seedpieces. The pots were kept on the greenhouse floor (14-22 C), and the germination of seedpieces was recorded 7 weeks after planting.

B. Applying TPM suspension to one-node seedpieces before covering them with soil. One node seedpieces of varieties L 60-25 and L 62-96 were placed in pots partly filled with soil infested with either C. adiposa or C. paradoxa. The seedpieces were then drenched with 100 ml of 0.35% (a.i.) TPM and immediately covered with more infested soil. Each pot contained 1,814 g of nonsteamed soil and 34 g of ground stalks infected with C. adiposa or C. paradoxa or uninoculated. Some seedpieces received only tap water and were planted in soil into which ground stalks had not been incorporated. Each replicate consisted of one seedpiece in one pot, and each treatment was replicated 5 times. The pots were kept on the greenhouse floor (6-14 C). Germination of seedpieces was recorded 6 and 10 weeks after planting.

C. TPM drenching of pots with growing plants. One-node seedpieces from each of 4 sugarcane varieties, CP 52-68, CP 61-37, L 60-25, and L 62-96, were planted in 15- and 23-cm diam pots and kept on greenhouse benches (21-36 C). When plants were 120 to 180 cm tall, 250 ml of 0.28% (a.i.) TPM suspension was applied to each potted plant. Two to 6 weeks after the application of TPM suspension, the main stalks were cut and then, by puncture method, inoculated separately with the spore suspension of the 3 pathogens (1). For 2 weeks, the inoculated stalks were kept in plastic bags with a little water in the bottom at room temperature (22 C). Stalks were then split, and the spread of the disease was recorded. Each treatment was replicated at least 3 times.

Stalks from TPM-drenched pots of the variety L 60-25 were cut into one-node seedpieces and planted in potted soils infested with the three pathogens together. Also, stalks from non-drenched pots were used. Each treatment had 10 one-node seedpieces. The pots were kept on the greenhouse floor (18-26 C). Germination of seedpieces was recorded 4 and 6 weeks after planting.

RESULTS

A. Dipping one-node seedpieces in TPM suspension before planting. Germination of seedpieces of the 5 tested varieties not protected by TPM but inoculated with C. adiposa was 40% or less. With C. paradoxa, it was 10% or less. The germination of variety CP 44-101 inoculated with C. falcatum was 30%. The seedpieces of the other 4 varieties were not tested against C. falcatum. However, germination was more than 80% for TPM-treated seedpieces of all the varieties inoculated with the two Ceratocystis spp. and of CP 44-101 inoculated with Colletotrichum.

Data on the control by TPM of the 3 pathogens together are summarized in Table 1. In the uninoculated seedpieces, except the variety L 60-25, the germination percentage was greater in TPM-treated seedpieces than in the untreated seedpieces. Among the inoculated seedpieces, germination percentage of seedpieces not protected by TPM was greatly reduced: only 5 or less of the 100 seedpieces not protected by TPM germinated. However, when the inoculated seedpieces were protected by TPM, they germinated as well as or better than the uninoculated seedpieces.

All three pathogens were isolated from the unprotected, ungerminated seedpieces, but *C. paradoxa* was found more often than either of the other two. None of the pathogens were isolated from the TPM-protected, but ungerminated, seedpieces.

Table 1. Effect of TPM (0.7%, a.i.) on germination percentage of seedpieces of 5 varieties in the presence of 3 pathogens (*Ceratozystis adiposa*, *C. paradoxa*, and *Collectotrichum falcatum*) together. ^{1/}

Treatment		Variety				
Fungicide	Pathogens	CP 44-101	CP 52-68	CP 61-37	L 60-25	L 62-96
TPM	Water	95	100	80	85	100
	Pathogens	85	90	75	90	85
Water	Water	60	85	45	90	60
	Pathogens	0	0	0	0	5

^{1/}Reading was taken 4 weeks after planting. Percentage was based on 20 seedpieces of 2 experiments.

When the one-node seedpieces of varieties CP 61-37 and L 62-96 previously immersed in 0.7% (a.i.) suspension of TPM were potted in soils infested with 3 pathogens together, 80% of the TPM-protected seedpieces germinated, whereas 10% or less of the seedpieces not TPM-protected germinated.

The germination of seedpieces of varieties CP 61-37 and L 62-96 immersed first in 0.21% (a.i.) TPM suspension, then in a mixed spore suspension of the 3 pathogens, and then planted in nonsteamed soil was similar to that of those planted in steamed soil. One of 9 inoculated seedpieces not protected by TPM germinated, whereas 5 of 9 of those protected germinated.

B. Applying TPM suspension to one-node seedpieces before covering them with soil. In soils not infested with the *Ceratozystis* spp., the germination percentage of seedpieces of varieties L 60-25 and L 62-96 was greater when the seedpieces were planted in soil without incorporation of ground stalks than when planted in soils with incorporation of ground, uninoculated stalks (Table 2). By the addition of TPM to seedpieces and to soils incorporated with the ground, uninoculated stalks, the germination percentage of seedpieces of both varieties increased (Table 2).

Table 2. Effect of TPM (0.35%, a.i.) on percentage germination of seedpieces when the fungicide was applied to the seedpieces planted in soils infested with *Ceratozystis adiposa* or *C. paradoxa* before being covered with soil.

Treatment		Varieties	
Fungicide	Inoculum	L 60-25	L 62-96
TPM	Uninoculated control	90	80
	<i>C. adiposa</i>	50	40
	<i>C. paradoxa</i>	90	80
Water	Uninoculated control	50	40
	<i>C. adiposa</i>	0	0
	<i>C. paradoxa</i>	0	10
Water	Soil only ^{1/}	80	90

^{1/}Soil not incorporated with the ground stalks.

In the Ceratocystis-infested soil, the germination percentage of seedpieces of both varieties not protected by TPM was greatly reduced, compared to those protected by TPM. The germination percentage of seedpieces in TPM-treated and C. adiposa-infested soil was less than than in TPM-treated and C. paradoxa-infested soil (Table 2).

C. TPM drenching of pots with growing plants. When seedpieces from whole stalks, harvested from potted plants that had been drenched with 0.28% (a.i.) TPM suspension 2 to 6 weeks earlier, were inoculated separately with the 3 pathogens, the pathogens did not spread from the inoculation sites. The pathogens did spread from the inoculation sites in stalks from plants not so protected; fungi similar to the 3 pathogens were reisolated. No pathogens were recovered from the treated, inoculated stalks.

More than 90% of seedpieces of L 60-25 from the plants that had been root-drenched with TPM suspension 6 weeks before they were cut germinated when planted in potted soils infested with the 3 pathogens. In contrast, less than 20% of seedpieces from the untreated plants germinated.

DISCUSSION

The results from these greenhouse experiments showed that TPM increased the germination by protecting the seedpieces against the 3 pathogens. TPM can be applied either as dip treatment of seedpieces before planting, to seedpieces and soil at time of planting, or as root drench to growing plants. Treatment of seedpieces with TPM to control soil-borne diseases may be of commercial value.

The germination percentage of seedpieces in TPM-treated and C. paradoxa-infested soil was greater than that in TPM-treated and C. adiposa-infested soil (Table 2). This result suggests that a higher concentration of TPM may be required for a satisfactory control of C. adiposa than that for C. paradoxa.

The 3 pathogens were reisolated from the nontreated and inoculated stalks, but not from the treated and inoculated stalks. TPM or its metabolic product in the stalks kills the 3 pathogens.

The application of TPM to growing plants appears to be the most promising method under conditions found in Louisiana. There, the red rot pathogen is transmitted in or on seedcane that is taken from stalks already infected as growing cane (2). To suppress active internal growth of the pathogen and prevent infection of the uninfected tissues in stalks, it is important that the effective level of TPM or its metabolic product be present in stalks of growing stalks before they are cut for seedpieces. Root drench of the growing cane with TPM before harvesting for seedpieces may satisfactorily prevent the transmission of red rot pathogen in the seedpieces by the soil-borne pathogens, as well as by the red rot pathogens on the seedpieces.

The results obtained with one-node seedpieces in the greenhouse do not apply directly to field experiments. The buds on short seedpieces are less protected from soil-borne pathogens than would be the buds toward the centers of whole stalks used as seedcane. The protection afforded by the nodal plates that arrest or retard the spread of pathogens is not available in short seedpieces. Also, field soil with its diversified microflora may reduce the concentration of soil-borne pathogens more rapidly than inoculated steamed soil.

Further studies are in progress to determine the effect of TPM under field conditions to control the soil-borne pathogens. If the results are as promising under field conditions as those in the greenhouse, more studies will be required to determine (a) what the most effective method would be of applying TPM to the growing cane under field conditions so that the fungicide would become systemic in stalks before they are cut for seedpieces, and (b) whether or not TPM or its metabolic product would persist in seedcane or seedpieces until the next spring under field conditions.

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MASS SCREENING OF SUGARCANE SELECTIONS
FOR EYE SPOT RESISTANCE

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ABSTRACT

Outbreaks of eye spot (caused by *Helminthosporium sacchari*) in the sugarcane variety CP 57-603 in the last 5 years have emphasized the need for eye-spot resistance in commercial varieties in southern Florida. To obtain the desired agronomic characters, sugarcane breeders must use some susceptible parents and screen susceptible individuals out of the resulting progenies. In order to increase efficiency in the breeding program, the screening must be done in early selection stages when populations are large; thus mass screening methods are required. A method involving the dispersal of inoculum over sugarcane in the field from a tractor-mounted power sprayer was used at Canal Point in Stage I and Stage II plantings in the winters of 1972-73 and 1973-74. Conditions were highly favorable for eye-spot development in 1972-73 and much less favorable in 1973-74, but disease development and classification of clones for eye-spot resistance were adequate in both years. Inoculation was done at night in order to take advantage of dews and higher relative humidities that promote infection. Blackstrap molasses (5% by volume) added to the inoculum substantially increased infection.

THE EFFECT OF NUMBER OF CULTIVATIONS ON SUGARCANE
PRODUCTION IN LOUISIANA ^{1/}

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ABSTRACT

Six experiments were conducted during 9 years to determine the importance of the number of postplanting cultivations on sugarcane yields in Louisiana. Fields in good condition, not heavily infested with johnsongrass, yielded well regardless of the number of cultivations. However, fields heavily infested with johnsongrass yielded better when cultivated often. In all fields, weed infestation gradually increased with less than 3 cultivations. Also, lodging was generally more severe and harvesting was more difficult with only one or two cultivations. Three or 4 cultivations appeared to be optimum.

INTRODUCTION

The typical cultivation scheme for sugarcane has been: (a) cultivation of the row after planting in the fall, (b) shaving of weeds and frozen cane growth in the spring, (c) off-barring, (d) fertilization, (e) rebuilding rows, (f) disc-cultivations at 2- or 3-wk intervals, and (g) lay-by (last cultivation).

Cultivation regimes in Louisiana have recently been modified. Hebert and Matherne (1) reported that shaving is beneficial only to remove excess soil covering seed cane, high stubble, winter weeds, or dead terminal buds near the soil surface. Hebert and Matherne (2) also reported no difference in yields between off-barring and modified off-barring i.e., bringing the soil back in the same operation. Rodrigue (8) reported satisfactory results with this method of off-barring. Hebert and Matherne (3) found no differences in yields between early lay-by and late lay-by.

Matherne (4) reported that the number of cultivations could be reduced without reducing yields. Ricaud (6) found yields with no, one, two, and three cultivations equal to those with six cultivations in plant cane and first stubble crops, if weeds were controlled. Millhollon (5) reported that a fall application of herbicides kept sugarcane free of winter weeds and increased yields.

Most of these modifications have become common practice. Cane is rarely shaved in the spring, is no longer left on the off-bar, is cultivated five or six times, and is laid-by earlier.

Sugarcane is planted during August, September, and October on ridges (rows) about 12 to 15 inches high. High rows are important for surface drainage and facilitate harvesting with the soldier harvester.

This paper summarizes results from experiments on the number of cultivations that affect sugarcane yields.

MATERIALS AND METHODS

Six experiments were conducted during 9 yrs to determine the effect of the number of post-planting spring cultivations on sugarcane yields in Louisiana. Johnsongrass (Sorghum halepense (L.) Pers.) is the most important weed problem in sugarcane in Louisiana. Because it bears directly on the minimum number of cultivations needed for optimum sugarcane yields, these experiments were conducted in areas of light, medium, and heavy johnsongrass infestations.

Light johnsongrass area. Experiment A was conducted on the Mayo Romero Plantation, Jeanerette, La. in 1964. It was on Baldwin silt loam with variety CP 52-68. The experiment had a randomized block design with four replications, and plot size was 1/24 acre. Fertilizer,

^{1/}Research at this location is done in cooperation with the Louisiana Agricultural Experiment Station.

herbicides, and insecticides were applied by airplane. Treatments consisted of no, two, and three cultivations. Plots with two cultivations received a modified off-barring and a lay-by cultivation in late May. Plots with three cultivations were treated similarly, but received an extra cultivation in late April.

Experiment B was conducted at the Houma Sugarcane Laboratory, Houma, La. in 1970. The soil was Mhoon silt loam; variety CP 52-68 was used. Plot design was similar to that of Experiment A, but plot size was 1/35 acre. Treatments consisted of one, two, three, four, and five cultivations. Plots receiving one cultivation were given only the modified off-barring cultivation and were fertilized in one operation. Plots receiving two, three, four, or five cultivations were similar to those of Experiment A, but the timing of each cultivation depended on the number of cultivations.

Moderate johnsongrass area. Experiment C was conducted on Point Farm Plantation, Montegut, La. in 1968. The soil was Mhoon silt loam, the variety was CP 55-30. Plot size was 1/2 acre, with design and treatments similar to those of Experiment B.

Experiment D was planted on St. Michel Plantation, Houma, La. in 1968. The soil type was Commerce silt loam; the variety was CP 55-30. Plot size was 1/8 acre, with design and treatments similar to those of Experiment B.

Heavy johnsongrass area. Experiment E was planted on Southdown Plantation, Houma, La. in 1965. The soil was Mhoon silt loam with variety CP 55-30. Plot size was 1/35 acre, with design and treatments similar to those of Experiment B.

Experiment F was planted on Southdown Plantation, Houma, La. in 1967 on Mhoon silt loam with variety CP 55-30. The experiment was identical to Experiment E.

RESULTS

Yields were not significantly different for no, two, and three cultivations in Experiment A (Table 1). This was in a low-johnsongrass area, and weed control was good throughout the growing season. Rows were visibly lower with no and two cultivations than with three cultivations. Unfortunately, the experiment was not continued through first- and second-stubble crops.

Table 1. Average yields of cane per acre for number of cultivations on plant cane (CP 55-30) with light johnsongrass infestation. (Experiment A).

No. cultivations	Yield of cane/acre	Row height (in.)
	Tons	
0	33.4	9.0
2	35.3	8.0
3	32.5	12.5
LSD 0.05	N.S.	

Experiment B (Table 2) was also in a low-johnsongrass area. Good weed control was maintained for all plots, and no significant differences between treatments were found. Rows were lower in the one- and two-cultivation treatments.

Results for Experiments C and D, in a moderate-johnsongrass area, were similar, and were combined (Table 3). Johnsongrass somewhat increased in the stubble crop, but remained light for all treatments. Yields did not differ significantly between treatments.

Results for Experiments E and F, which were in a heavy johnsongrass area, also were combined (Table 4). Weed control was only fair for the plant cane crop, and yields showed no significant difference between treatments. Johnsongrass increased considerably in the first stubble crop. Plots receiving 5 cultivations yielded significantly better than those with one cultivation, but not significantly better than those with two cultivations. Johnsongrass was extremely heavy in the second-stubble crop. However, the infestation was not equally distributed in the experiment and resulted in a high C.V. of 22.16%. The difference between two and five cultivations, although 6.6 tons per acre, was not significant.

Table 2. Average yields of cane per acre for number of cultivations for plant cane and first- and second-stubble crops (CP 52-68) with light johnsongrass infestation. (Experiment B).

No. cultivations	Yields of cane/acre (tons)		
	Plant cane	First stubble	Second stubble
1	26.9	36.5	18.6
2	29.8	36.1	20.3
3	30.0	36.4	24.7
4	30.4	34.4	21.0
5	31.6	36.4	23.2
LSD 0.05	N.S.	N.S.	N.S.

Table 3. Average yields of cane per acre for number of cultivations for plant cane and first-stubble crops (CP 55-30) in an area of moderate johnsongrass infestation. (Experiments C and D).

No. cultivations	Yields of cane/acre (tons)	
	Plant cane	First stubble
1	30.1	25.6
2	30.1	25.3
3	32.0	26.2
4	31.4	26.0
5	32.3	27.4
LSD 0.05	N.S.	N.S.

Table 4. Average yields of cane per acre for number of cultivations for plant cane and first- and second-stubble crops (CP 55-30) in an area of heavy johnsongrass infestation. (Experiments E and F).

No. cultivations	Yields of cane/acre (tons)		
	Plant cane	First stubble	Second stubble
1	24.4	24.5 b*	20.1
2	28.1	26.3 ab	17.6
5	26.6	27.4 a	24.2
LSD 0.05	N.S.		N.S.

*All means followed by the same letter do not differ significantly by the Duncan Multiple range test.

DISCUSSION

Results obtained from these experiments indicated that the number of cultivations had no effect on sugarcane yields if weeds were controlled. In areas of no or moderate johnsongrass, 4 to 5 cultivations exceeded needs. In areas of high johnsongrass, infestation however, 5 cultivations were needed to maintain maximum yields.

The recommended cultivation scheme most generally followed throughout the sugarcane belt is as follows. Sugarcane fields are sprayed with a residual pre-emergence herbicide after planting (August, September, October). The herbicide treatment (band application) is not disturbed during the fall and winter unless weeds are emerging(5). Occasionally, a fall cultivation is given if erosion of the row threatens to expose the seed cane to cold damage.

Summer or fall planted cane or stubble cane killed by freezes is generally not shaved in the spring (1) unless severe freezes damage all the buds near the surface. In this case, the damaged tissue is shaved off to enhance germination of the lower buds.

The cane is off-barrred and the soil brought back at the same time (2). This off-bar cultivation is generally completed in March. Fertilizer is applied in April and May (7). Often fertilization and cultivation are done in one operation. If cane is fertilized in April, another cultivation is often given in early May.

Spring application of herbicides (band application) is not disturbed by cultivations, at least until lay-by. The lay-by cultivation is made in late May or early June, depending on height of the cane crop (3).

The results of these experiments showed that the minimum 3 cultivations recommended in this general scheme - i.e. - at the time of off-barring, fertilization, and lay-by might be excessive in areas of light or moderate johnsongrass infestation. There was no significant difference in yield of cane between 3 cultivations, and fewer cultivations, providing good weed control was obtained.

Often, however, the cultivations at the time of off-barring and fertilizing are more necessary in practice, than under the conditions of these experiments. Stubble fields are often deeply rutted at harvest and a considerable amount of scrap is left in the field. Heavy soils are in very poor physical condition, compacted by heavy fall and winter rains. These 2 cultivations could be essential to destroy trash and restore soil structure to obtain maximum efficiency of fertilizer, particularly gaseous or aqua ammonia. Conceivably, elimination of one or both of these 2 cultivations, under these conditions, could result in a decrease in cane yield.

Furthermore, it was noted that weed infestations did, in fact, increase slightly in the stubble cane of the 0 cultivation treatments (data not shown). If this increase were progressive it could conceivably cause a significant yield reduction in the next or succeeding crop cycles.

The lower row height resulting from the omission of the lay-by cultivation could be a significant factor in the harvesting of badly lodged fields. Conventional Louisiana harvesters leave considerably more scrap when operated on these relatively flat rows.

When one or more of the above conditions prevail, yield could be reduced if the number of cultivations is reduced below the 3 minimum cultivations now recommended. Whether or not these conditions prevail and whether or not a cultivation can be omitted is basically an on-the-spot management decision. These results show, however, that 4 or 5 cultivations would exceed needs in areas of light johnsongrass infestation but result in better yields in areas of heavier johnsongrass infestation.

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A REVIEW OF SUGARCANE BORER CONTROL IN LOUISIANA

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ABSTRACT

Ryania, endrin and azinphosmethyl are insecticides that have been used to control the most destructive insect pest of sugarcane in Louisiana during the last 20 years. The sugarcane borer (*Diatrea saccharalis* (F.)) was probably introduced into Louisiana in the nineteenth century from South America, and from 1937 to 1957 reductions in sugar yields have averaged 13% annually. Presently the industry depends largely on insecticides to control this pest, but applications have been reduced from as many as 12 applications in 1956 to an average of 1.5 applications in 1973. Weekly field surveys are now recommended and only cane having at least 5% infestation is treated. This 5% level is considered to be the economic injury threshold, and the establishment of this level has been largely responsible for reductions in the number of applications applied. Cane is re-treated only when this 5% level reoccurs. This system of control eliminates fixed schedules for applications, is very effective, and allows emphasis to be placed on varietal resistance, climatic conditions, and the effects of native arthropod predators on borer populations.

INTRODUCTION

Of the insects that attack sugarcane in Louisiana, the sugarcane borer (*Diatrea saccharalis* (F.)) is the most destructive. From 1912 to 1950, annual losses ranged from 4 to 30% (2, 6). Based on a factory survey method at harvest time, Charpentier et al. (1) reported that a 5 million dollar loss occurred in 1968.

This insect is believed to be native to the West Indies and South America. It was observed in this country prior to 1856 and is now established in parts of Florida, Mississippi, Texas, and Louisiana. Other hosts involved include corn (*Zea mays* L.), rice (*Oryza sativa* L.), Johnson grass (*Sorghum halepense* L.), and sorghum (*Sorghum vulgare* Pers.).

NATURE AND EXTENT OF DAMAGE TO SUGARCANE

Borer attacks may cause any of the following types of damage: deadhearts in young plants; dead tops in elder plants; reductions in weight of mature stalks; reductions of sucrose content; injury to seed cane by increasing the occurrence of fungus diseases (4, 5).

SEASONAL HISTORY AND DESCRIPTION OF STAGES

In Louisiana, 4 or 5 generations occur each year. The first generation attacks the crop in May and June before the young tillers have formed internodes above the soil surface. Second and third generations infest stalks in July and August injuring stalks that contribute most to sugar yields. Fourth and fifth generation infestations occur in September and October but are mostly restricted to the immature top internodes which contribute little to sugar yields (3).

The adult of the sugarcane borer is a straw-colored moth having each forewing marked with black dots in a V shape design. The size of the moth varies, but the average is 1 inch from tip to tip of the spread wings.

The eggs are flat and elliptical and are deposited in clusters on the leaf surface, overlapping in a fish-scale manner. Each cluster contains approximately 2 to 100 eggs, although the average is about 25 and is usually less than 50 (4).

The larva is approximately 1 inch in length when fully grown. It is yellowish with brown spots. There are 5 instars (3) and the young larvae migrate to and feed in the spindles and leaf sheath areas before entering the stalk. The entire cycle is completed in 30-40 days.

CONTROL

The Louisiana sugarcane industry has depended largely on insecticides to control this pest. Ryania, endrin and azinphosmethyl have played important roles in providing adequate control

although the number of applications required has been reduced significantly during recent years.

In 1956, as many as 12 routine applications were recommended to control this insect. In 1958 growers were advised to apply 2% endrin granules 4 times at 14 day intervals (7), but little emphasis was placed on field surveys to determine levels of infestations. In 1962, recommendations were modified to place greater emphasis on the need for continuous field checking during June, July, and August in order to determine the need and effectiveness of treatments (7). The 5% level of infestation as the economic threshold level was introduced, and growers were advised to treat plants only when this level was reached. Re-treatment is recommended only when this level is reached again. This system eliminates fixed numbers of applications of insecticides, and in 1973 the borer was controlled in Louisiana with an average of 1.5 applications of azinphosmethyl.

This pest management system allows one to take advantage of other methods of insect control. Varietal resistance is one of the most important, and greater emphasis is being placed in this area in breeding programs. Arthropod predators are allowed to contribute in controlling this pest. Hensley *et al.* (8) have reported a complex of arthropod predators as the most effective of all biological control agents present in Louisiana sugarcane fields. This complex of predators is especially important during the early summer and is responsible for delaying insecticide applications in many cases. Climatic conditions suppressive to borer populations can be detected and are often responsible for a reduction in insecticide need.

CONCLUSIONS

The management of pests is not a new idea, but its strong advocacy today is a product of our times. The Louisiana sugarcane industry has been using this pest management system for several years and many feel that a healthy situation is being reached. Continued emphasis on weekly field surveys, taking advantage of varietal resistance, protection of non-target organisms, and continued research on economic injury thresholds are a must in order to maintain an effective control program.

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SAND LAND SUGARCANE

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ABSTRACT

During the summer of 1972, A. Duda and Sons, Inc. decided to establish an experiment with sugarcane on sand land near LaBelle, Florida. The initial experiment consisted of approximately 300 acres. Varieties of cane grown were: CP 62-588, CP 56-59, CP 62-374, and others in small quantities. As a result of this experiment 12,000 tons of cane were harvested with an average of approximately 46.6 tons per acre and an average sucrose percentage of 14.50. Harvesting was accomplished primarily by hand and approximately 50 acres by mechanical harvester. Ratooning was observed after harvesting and appeared to be satisfactory with all varieties.

EVALUATION OF SUGARCANE HARVESTER COMPONENTS BY USE OF HIGH-SPEED PHOTOGRAPHY

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ABSTRACT

Sugarcane harvesters for gathering, topping, cutting, and cleaning recumbent sugarcane have several components which operate in the cane. It is difficult to see the components through the material, and it is impossible to assess the effect on the cane root, on the cane stalk, or the trash removal efficiency of fans. Several components have been observed in action by mounting a high-speed movie camera on the harvester. The rotary cutting discs, chopping knives, suction fans, and other components which operate at top speeds of 500 to 10,000 feet per minute can be observed in slow motion when the film is projected. The action of the harvester device, the reaction of the cane, and the degree of damage to the stalk can be observed and speeds of the materials measured from the film. This technique has proven especially useful in evaluating the type of cut made by the high velocity chopping knives and the trash removal and cane loss through suction fans. The results of these studies have been made available to harvester-design engineers, and movies have been made at the request of the engineers. Examples of the films taken of circular cutting discs, chopping knives, cleaning rolls, and suction fans will be shown during the presentation. The camera speed for the several components was 500 to 4,000 frames per second and it will be projected at 24 frames per second.

INTRODUCTION

A high-speed photographic camera makes possible visual observation of the contact of a biological material, such as sugarcane, with the rotating mechanisms on the harvesting, handling, or cleaning equipment. On conveying mechanisms, the movement of sugarcane generally is a blur when observed with the unaided eye. When this movement is slowed while projecting the high-speed film, not only can the contact of the material be observed, but there are actually voids in the movement of the material that are not noticeable to the unaided eye.

Movie film is generally considered to be high-speed when the framing rate is more than 64 frames per second. Some observations can be made by using a regular 16 mm movie camera having filming rates of 32, 48, or 64 frames per second. High-speed movie cameras may be obtained for filming up to 500, 5,000, 5 million, or even 14 million pictures per second (1). Most equipment uses 16 mm film and has a filming rate below 10,000 frames per second. The high-speed movie camera used in the photographic analysis of sugarcane harvesting and cleaning components uses 100-foot rolls of 16 mm film, and filming rates are generally between 500 and 4,000 frames per second.

The camera is mounted on the frame of the harvester or close to a harvester in the laboratory. About 6 or 8 floodlamps of 750-watt capacity are used when the device being filmed is not in the sunlight. The camera operates for only 3 to 4 seconds for the normal 100-foot roll of film and the film lasts 3 to 4 minutes when viewed at 16 or 24 frames per second. The flow of sugarcane begins before the camera is started and continues for the time necessary to complete the roll of film. The best technique for using the camera is to mount it directly on the frame of the harvesting machine in the field. This technique provides normal operating conditions and assures a plentiful supply of cane during the photographing period.

MATERIALS AND METHODS

Cameras in the lower speed ranges may be of the intermittent type, which start and stop the film for each frame. Cameras in the higher speed range use rotating prisms, rotating mirrors, or similar devices that focus and wipe the image on the moving film. A camera of the intermittent or rotating prism type may be purchased for about \$2,500, and the speed control, lighting, and associated equipment for another \$3,000.

Because of the acceleration of the film, the filming rate is not constant throughout the entire length of the film. Some cameras have electronic speed-control units that maintain a constant filming rate after the initial film acceleration. For this reason, and because of distortion of the image by optical systems, a size and time relationship should be provided on the

film. The relationship can be provided by placing grids and rotating discs in the picture or by using timing lights that expose a mark on the film border.

Simple data reduction can be accomplished by using a standard 16 mm motion picture projector having a still-picture control. The analysis can be made from visual observation alone, or the mechanism and particle relationships can be measured on the screen. Special projectors for motion analysis provide start and stop movement, individual frame viewing, or viewing at such frame rates as 1 or 2 pictures per second. Other manual and computerized data reduction systems are being used as the technique gains wider usage.

The sprocket holes for the camera drive mechanisms are more accurate in high-speed movie film than they are in lower-speed film. Some systems require higher strength film than others to prevent film breakage during the acceleration. Typical costs for 100-foot rolls of black and white film are about \$4.00 for the film and \$5.00 for processing. Color film usually costs about \$5.50, and the processing about \$6.30.

Although some movies can be taken in direct sunlight, artificial lighting of 10,000 to 30,000 foot-candles of brightness is usually necessary to illuminate the area being photographed. Any type of lighting may be used, but generally 500- to 1000-watt floodlamps are sufficient. The lighting may be more difficult than the camera arrangement when taking movies in close spaces. Some materials being photographed may dry or burn from the heat of the floodlamps if the lamps are too close to the materials. Reflections may be a problem when photographing through glass or plastic panels. The space available for installing the camera and lights should be considered when selecting the equipment. The size and orientation of the camera, the size of the film magazines, and the number of lights needed - all should be considered.

Since the accuracy of the data from high-speed photographs depends on the accuracy of recording the individual setup, a standardized system should be used. The location of the camera and all information concerning such factors as lenses, film, and lighting should be recorded on a form. It is a good idea to take a photograph of the equipment for reference in case an identical setup is needed later, or for reference by a different person using the equipment.

Calculations to determine the proper camera speed can be made by considering the speed of the objects and the desired viewing characteristics. Just as with still photography, a trial film may be the best method of determining proper settings. It is advisable to take several rolls of film while operating because of the time and expense involved in the filming operation, particularly that associated with setting up the equipment. A different encounter between moving objects usually occurs during each roll of film. Since the camera's operating time may be only 2 to 5 seconds, and the film is accelerating during some of this time, the amount of usable film is limited.

Special films may be used for such applications as recording temperatures of materials or gases. This technique is used in the development of jet engines and rockets. High-speed photography is used to record the launching of space probes. In highly explosive installations, cameras may be triggered by shock from accidental explosions. The results may then be used to determine their cause.

RESULTS AND DISCUSSION

Several rolls of high-speed movie film were taken in Florida, and technical observations and measurements were made from the film. Twelve types of circular base cutters were photographed in sugarcane in an analysis of methods of cutting cane at the ground on the soft muck soils in Florida. Dual 24-inch-diameter circular base cutters having mower sections attached were photographed at 2,680 and 3,918 fpm tip speed. A single 42-inch-diameter base cutter with continuous rectangular segments around the periphery was photographed at a tip speed of 3,755 feet per minute. The camera operating speed was 1,750 frames per second, and the travel speed of the harvester was 1.5 miles per hour in both cases. The cane stubble was cut slightly high so that soil would not be thrown into the area being photographed.

The mower segments of the 24-inch-diameter cutters are intermeshed and timed so that they overlap as they rotate. They were designed in this manner so that the intermeshing segments would shear the cane stalk if it was not cut by the rotating blades. The advance of the cutting segments needed to cut the stalk were observed. Six to 12 segments generally contacted the stalk before it was completely severed. A better cut was provided with the 3,918 fpm tip speed, with less forward acceleration and less splitting of stalks than with the 2,680 fpm tip speed. Practically all of the stalks were cut by the leading edge of the cutters, and overlapping of the rotating segments is not necessary.

The periphery of the 42-inch-diameter cutter acted like a smooth rotating disc and accelerated the stalks toward the front. The continuous segments on this cutter did not give the stalks a rapid shearing force and either broke the stalks or pushed the roots from the ground. The stalks were moved away from their original location so that it was difficult to convey them through the narrow opening on the machine.

High-speed movies were made of the 3-bar and 5-bar reciprocating sickle-bar crossflow cutters on the harvesters in Florida. This method of chopping cane into short lengths was developed in Hawaii as a self-feeding cutter that would chop cane containing rocks with a minimum of damage. These photographs were taken with the machine stationary and as cane was fed by hand into the pickup mechanism. The camera was mounted in front of the machine near the point where stalks entered the pickup system. The filming rate was 500 frames per second. It is not possible to observe the action of this crossflow cutter with the unaided eye. It has been generally thought that it is impossible for a stalk of cane to get through the cutter bar without being completely severed. In slow-motion viewing however, we observed that some stalks bypass the cutting area and get through the cutter without being severed. Other stalks are pushed toward the tip of the cutting segments and are not completely cut.

Photographs were taken to view the cutting action of the drum-type chopper with intermeshing axial blades that feed and chop the cane. These photographs were taken at 1,000 frames per second on a harvester operating in the field. The chopping drum was 6-feet wide and was divided into 2 sections to equalize the torque load as it rotated. The entrance of the cane into the drum chopper and the discharge of the pieces were visible in this photograph. The blades on the drum fed the cane between the choppers and gave little interference with the flow. The discharge of the chopped material into the area beneath the suction fans was also visible in the film.

Movies were made of a 24-inch wide, overlapping blade-chopping mechanism in a harvester. These blades were sharpened on one edge and the beveled blades overlap as they rotate. The speed of the feed rolls that convey sugarcane into the chopper was changed from 110 to 180 rpm to determine the difference in action. This change increased the cane length from 10 inches to 13 inches.

Movies were made of 2 types of swinging-knife chopping mechanisms cutting through the cane in the feeding system of the harvesters. The first type of chopping knife used as interchangeable hub that could be equipped with 1, 2, or 3 blades to change the length of cane pieces. The unit rotated at a tip speed of 10,000 fpm and was located at the side of the feeding rolls to cut across a 24-inch-wide swath of cane. The cane moved through the machine at 2,330 fpm as it was chopped. The small chaff from the cane stalks, which could not be seen with the unaided eye, was caused by the rapid acceleration of the stalks by the feed rolls. One picture illustrates how the cane was forced against the chopping knife as the knife moved through the cane. This contact caused a frayed edge on the end of the piece that was forced against the blade. These photographs vividly illustrate where organisms can enter the split cane and cause it to dehydrate and deteriorate.

The second type of chopping knife consisted of a single blade on a hub cutting an 18-inch-wide mat of cane. This knife was positioned so that it cut across the top of the mat; whereas, the other cut from the side. The thickness of the cane was about 6 inches, so a smaller diameter hub and knife was used and it rotated at a tip speed of 5,715 fpm. This knife did not fray the stalks, since the material was moved through the machine at only 400 to 500 fpm as it was chopped.

The contact of air from blowers and suction fans with the cane that was discharged from a conveyor was visible on the high-speed movie film. The cane discharged from the conveyor at 300 fpm, and the air blast traveled at 5,000 fpm and was discharged immediately below the conveyor. The air lifted the light trash from the cane pieces and blew it from the rear of the harvester as the cane fell into the loading conveyor.

The observation of the contact of air from a suction fan with material was not a very dramatic view, but the continuous movement of small trash from the cane mat was visible. The trash was lifted from the cascading mat of cane, and the trash was pulled through the fan blade and discharged into the surrounding area. Many heavy pieces of trash were lifted, but the velocity was not sufficient to remove them.

The action of the spike-tooth drum-conveying cylinders and the application of suction above the cylinders were visible on high-speed movie film. In this application the spike-tooth conveying cylinders are located immediately behind the chopping mechanism in the harvester. The conveying cylinders break up the mat of cane, spread it into a fluidized layer, and break apart pieces of cane that have only partial cuts. The cylinders drop some soil, but primarily prepare the cane for pneumatic cleaning.

An interesting photograph was one showing the contact of trash and cane with rubber husking rolls that pull the leafy material through the rolls while the mature cane remains above the rolls. The use of color film allowed observation of the amount of green and dry trash removed by the cleaning rolls. The mature cane lost through the rolls was easily seen with this camera technique.

SUMMARY AND CONCLUSIONS

Visual observation and study of rotating components and a comparison of the results of similar devices was made by using a high-speed movie camera for recording the action. Good cuts can be made at the base of the sugarcane stalks with circular blades with spaced segments rotating at tip speeds in the 4,000- to 6,000-foot per minute range. It is not necessary to overlap the cutting edge of dual base cutters since all stalks are cut before they mesh.

Four types of blades for chopping cane stalks into short pieces were compared. The knife that swings through the cane flow should not interrupt the flow or split the cane. The blades that rotate and feed the cane should be designed to cut completely through the stalks.

The photographs of air from blowers and suction fans contacting the material indicated the paths of the trash and cane pieces. Better contact was made when air was applied close to cane with the blower, but the suction fan disposed of trash more easily. This suggests that a combination in which both systems are used would be beneficial.

Rotating cylinders for conveying and rubber rolls for cleaning were studied. The types of trash that dropped through the cylinders were observed. The color film gave a good visual indication of the amount of green and dry leaf material that was removed by the rubber cleaning rolls.

The researcher can devise many systems for producing the action he desires during photography. Depending on the field or crop situation, the product can usually be brought to the laboratory and the machine and camera kept stationary. However, it is more desirable to mount the camera directly on the machine in the field when crop conditions are normal and the timing of the camera and material is not as critical.

Power for the camera and lights can be furnished by utilities, portable generators, or batteries. In most instances a power supply of about 5 kw is needed, plus separate circuits for the camera and lights. If the object is in direct sunlight and the filming rate is not too high, a small battery for camera operation may be sufficient.

High-speed photographic analysis will not supply all the answers needed by engineers. High-speed photography is merely a research tool - just like a calculator, a recorder, or a computer. The camera is especially useful for determining the action and reaction between a mechanical device and an agricultural product. The photo-analysis described above is very valuable to assist in the final design and the performance of machine components.

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MECHANICAL HARVESTING AT THE GLADES COUNTY SUGAR
GROWERS COOPERATIVE ASSOCIATION

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ABSTRACT

Glades County Sugar Growers Cooperative Association began mechanical harvesting of sugarcane on an experimental basis using 4 machines during the 1972-73 harvest season. Approximately 10,000 tons of cane were harvested mechanically during that season with widely varying results. During the 1973-74 harvest season, 7 Massey-Ferguson 102 harvesters mounted on high flotation rubber were utilized, and these machines harvested a total of approximately 210,000 tons of our 700,000 total tons of cane. The conclusions reached by the mechanical harvesting operation this past season are that the Massey-Ferguson 102 harvester will harvest cane satisfactorily under the majority of our field conditions and can be integrated into our system of operation. It is the intention of Glades County Sugar Growers Cooperative Association to expand on mechanical harvesting in the future.

Glades County Sugar Growers Cooperative Association started seriously investigating mechanical harvesting prior to the 1972-73 harvest season. Our basic interest stemmed from the fact that we had from 40-50,000 tons of cane growing on sand land. Both we and equipment manufacturers felt that this cane could be harvested satisfactorily with a standard machine and that this use could then be expanded into the muck lands. On this basis, we reached an agreement with 3 manufacturers to try their machines during the 1972-73 crop, harvesting 3,000 tons by demonstration machines.

Our plans were to use the machines where possible to supplement regular deliveries of cane to the mill. The cane committed to the harvester operation consisted of cane that was to be removed after the crop. Our experience with this cane was that the trash content was very high and our ability to deliver cane on a regular basis was not very good. It became clear that man-power and transport would have to be committed to the harvester operation to obtain a satisfactory sample, as no chain is any stronger than its weakest link. Toward the end of the 1972-73 season we contracted with an owner of 3 machines for cane to be cut, loaded and hauled to the mill. We harvested 7,000 tons under this contract.

For the 1973-74 crop our sand cane-acreage increased appreciably. Because of this increase and the results obtained during the previous crop, we entered into negotiations with Massey-Ferguson for the 1973-74 season. It was determined at that time that one zone or front, which is Australian terminology, of 1,000 tons per day plus a satellite front of 200 to 400 tons per day would be manned with Massey-Ferguson 102 machines on high flotation rubber. It was expected that 4 machines would be assigned full time service on the main front, with an additional machine to be used as a stand by and 2 machines assigned to the satellite operation. The main front was to use the conventional side dump wagons pulled by 2-wheel drive sugar-babe tractors hauling to a transfer station for loading into highway haul vehicles. We assigned 2 tractors with wagons for each harvester.

The satellite unit loaded into triple-axle side-dump highway haul vehicles. This was the major source of hauling for this unit, with 2 high-lift side-dump wagons for hauling to standard highway trailer trucks as standby. The unit was assigned to harvest in an area of sand-land cane where we anticipated no problems with flotation or down cane. This area is similar to field conditions in Australia and other areas where satisfactory results are obtained with chopper harvesters.

Massey-Ferguson in their commitment to the Association brought mechanic-operators for training and operation of the harvesters. This allowed experienced operators to evaluate the capability and capacity of the machines in Florida conditions as well as to train local operators.

The Massey-Ferguson 102 is a relatively light weight, highly maneuverable, well balanced 2-wheel drive harvester which delivers a billet, or cane piece, from 10-12 inches long. It has twin base cutters and the elevator has the ability to discharge cane with a 180° [radius], which allows loading from either side or the rear. This unit will turn in a 20' headland and with hydrostatic drive gives speeds of 0-12 miles per hour. The tires used on the harvester are 12.0 x 18 front tires and 23.1 x 26 radial rear tires. Operating visibility is excellent and allows the operator to be in constant touch with the haul operation.

Massey-Ferguson's worldwide experience with these machines indicated an expected output of 200 tons per day. They estimated the pour rate (the rate the machine delivers cane into the wagon as it proceeds down a row) to be approximately 60 to 75 tons per hour. It was anticipated that 5 machines would be required to keep 4 machines in operation on the main front.

Based on the expected output, our harvesting schedule was set up so that the satellite unit would harvest sand-land cane and deliver approximately 400 tons per day for the season. The main front of machines was committed to a regular harvest schedule with anticipation of 1,000 to 1,200 tons per day.

Our plans were to evaluate the capacity of the harvester by creating as few variables as possible. This was done by substituting machines in the harvest only for cutters and continuous loaders. Using experienced operators we were able to determine the productivity of the Massey-Ferguson 102 in Florida conditions.

The main front operation started the season with 2 sugar babes with 3 wagons each per harvester. These units went to a transfer station for unloading. Almost immediately our experience indicated we could drop one wagon and actually gain time in the field. We were able to put from 5 to 6 tons of cane in a standard harvest wagon. With the increased maneuverability of 2 wagons this arrangement worked better than 3 wagons with a lighter load in each wagon. We operated at the beginning with 4 harvesters in the field, with the fifth harvester to open the new fields. Our experience with the machine indicated that the pour rate was double that anticipated and that we could safely expect over 300 tons per machine per day. Thereafter, we used only 4 machines for this main front.

The satellite operation, which was basically sand-land cane, was loaded directly into highway haul vehicles. We used 5 triple-axle trucks, 2 with 18' bodies and 3 with 22' bodies. The trucks worked well in conjunction with the harvester except that most of our sand-land cane has more irregularities in field size and shape. The trucks are not as maneuverable as tractors and wagons and require more headland for turning. A higher pour rate is required because of the time lost in turning. We found that we were limited in the distance from the mill that we could economically operate from due to turn around time. One major disadvantage of the tandem-axle trucks was the varying conditions under which the trucks had to operate. Maintenance was high due to the trash field conditions, plus slow loading speed required then onto highway for fast hauling to the mill.

When the distance from the mill exceeded 10 miles we supplemented the haul of these trucks with high lift wagons which transferred cane from the field into the standard tractor trailer trucks. The advantages of these units are the loading from either side and the ability to operate in extreme conditions. A major disadvantage was the capacity per unit, although we were able to deliver 300 tons of cane with 2 wagons on a number of consecutive days using only one harvester. These wagons were also used to open the fields as the trash build up on the radiators of the trucks was a problem in opening with trucks.

The first problem that had to be solved was the opening of each field. We tried many variations, from going circularly around the field to operating along one side only. The best solution was finally determined to be running down 3 rows in the middle of the field, then picking up these rows going the same direction as the cane had been run down. This removed 6 rows of the middle of the field and allowed for operating room. This method increased the trash because 3 rows were not topped. The advantage of this method was the shortened time required for opening plus the fact that once the field was opened all machines and field tractors were visible to each other.

Another major problem was down time of the harvester themselves. This was not a major factor last season except where created basically by field conditions. Rocks, pine knots, and other debris created quite a problem as no prior preparations were made for machine harvesting. A major problem could always be anticipated as a field was finished because of rocks, etc. on the ditch bank rows. Another problem encountered due to field layout was the necessity to cut some ditch bank rows by hand because the machine could not straddle the row without the danger of going into the field canal. The Massey-Ferguson 102 solved both problems of down-row and throw-over-row cane by handling most situations with ease. It was impossible to tell which rows were harvested this way when the field was completed.

Another problem was generated by the ability of the harvester to load more cane in our standard wagons than was possible with a continuous loader. This caused problems with the haul units in marginal field conditions and required constant monitoring to maintain proper load to prevent field damage. The extra weight carried over into a problem of overload on the highway units. With high fiber cane this allowed us to carry a full load for the first time, but with some varieties, like 374, we paid some rather large overweight citations.

Chopper harvested cane with its shorter billet increased the problem of deterioration of cane in pit storage. Use of the harvester dictated that cane must not be held over in the pit. This can be offset to a certain degree by the ability of the machine to go into the field shortly after the field is burned so that the cane is harvested and delivered to the mill not much more than 24 hr after burning.

When the season ended we had harvested 30% of our 700,000 tons by machine. Our trash average for the season was 4% above hand cut but the trash was different with the machine than hand as a major part of the percentage was made up of suckers and the heavier tops. The average tons per operating hour was approximately 30 tons for each machine. The machine did an excellent stubble job in almost all cases and the rattoning has been very satisfactory. The density of the load with the smaller billet has increased the load capacity of our trailers from 30-50% with a marked increase in density for the smaller barrel varieties.

Our conclusions after the full season were that the Massey-Ferguson 102 harvester will effectively harvest most of the cane grown for our mill and that although there are problems yet to be solved we will continue to expand mechanical harvesting as rapidly as possible.

GREEN AND BURNED SUGARCANE: A HARVEST COMPARISON

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ABSTRACT

Sugarcane is burned before harvest in Florida to reduce trash: dead and live crop foliage and weeds. Nonsugar-bearing plant material has practical and economic effects on harvesting and milling, while burning itself, and trash left in the field, affect agronomic practices. Research in this facet of sugarcane production was suggested by and supported partially by the Florida industry in response to current-day environmental concern. There is a paucity of information in the sugarcane literature on harvest comparisons between green and burned cane. Florida research compared manually-cut green and burned cane on a field-scale basis. Actual costs were not desired and were not obtained; green cane values were compared with the industry standard, preharvest burned cane. Paired sample units were scaled down to adjacent plots of about 7 acres when handling of large acreages of green cane affected mill operations and harvest scheduling adversely. Plant, first ratoon, and second ratoon crops of the recumbent variety Cl 41-223 were sampled in fields to be retained for successive harvest. Comparative data on 24 paired samples over a 3-year period were recorded for the following: hand cutting, loading, field and mill transport, tonnage, trash content, and juice quality. Supplementary data were taken as feasible and appropriate while agronomic observations were made in ratoon crops. The overall effects of harvesting green cane on a gross tonnage basis were: manhours in cutting increased 50%, continuous loader capacity per operating hour reduced 59%, field wagon transport capacity reduced 33%, mill transport unit capacity reduced 30%, and trash received at the mill increased 2.8 times. Differences between green and burned cane for the above comparisons were highly significant. The samples did not differ significantly in juice quality.

AERIAL APPLICATION RESULTS OF PARAQUAT TO HAND AND MACHINE
CUT SUGARCANE HARVESTED BY UNITED STATES SUGAR CORPORATION

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ABSTRACT

During the harvest season of 1973-1974, United States Sugar Corporation applied Paraquat dichloride as a foliar desiccating agent to over 5,900 acres of sugarcane. An aerial application program was initiated as an integral component of all mechanical harvesting operations. Since 1973-1974 was the first season mechanical harvesting units performed on a commercial basis for this corporation, the effects of Paraquat treatment prior to field burning can now be evaluated on a long term basis. The effects evaluated are: percent trash, by weight, of sugarcane as delivered to the Clewiston Sugar House; cane juice analysis on treated and untreated cane; degree of foliar desiccation and subsequent field burning results; and mechanical harvesting efficiency. Application techniques have been refined into a well-controlled program during the past 3 crop seasons. Some treatments were also applied to hand-cut sugarcane fields.

THE EVALUATION OF CHEMICAL HERBICIDES IN LOUISIANA SUGARCANE

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ABSTRACT

Several new chemicals are promising for weed and grass control when used pre- or early post-emergence in sugarcane. Asulam, alone or in combination with other materials, continues to show good control of johnsongrass growing from rhizomes. Several grass and broadleaf plant species that are not controlled with present herbicides in the market are now occurring in sugarcane fields. Reevaluation of some of the abandoned herbicides and combinations of the present chemicals in the market are being made in an effort to control these weed pests.

INTRODUCTION

The fallow plow program that was started in 1947-48 is still a good agronomic cultural practice that not only controls a high percentage of johnsongrass rhizomes but also leaves the soil in good condition for planting sugarcane.

Plowing the land to be planted to sugarcane in the late spring and summer not only kills most johnsongrass rhizomes but also causes many weed and grass seed to germinate and to be killed in the spring and summer. No chemical has been found that is as effective as the fallow plow program, regardless of cost for its application.

In the past 20 years many changes have been made in the agronomic practices of cultivation, fertilization, weed control, and other factors. The use of chemical herbicides has changed more in plant cane than the practices in stubble sugarcane.

PLANT SUGARCANE PROGRAM

Two long residual chemical herbicides are now registered and labeled for use in Louisiana sugarcane. These materials are fenac plus silvex (or 2,4-D) and sinbar. Fenac was originally recommended to be used with a phenoxy compound, but the phenoxy compounds have never aided sinbar; therefore, sinbar is recommended for use alone. As sinbar continued to be used, some weeds have shown an ability to grow and resist the chemical, and some were never controlled by either fenac plus silvex or sinbar. Browntop panicum is almost completely resistant to sinbar but highly susceptible to fenac plus silvex. Some other broadleaf weeds and grasses may be in this same category.

Two new chemical herbicides have shown promise as a pre-emergence compounds. These are sencor from Chemagro and EL 103 from Elanco. These are still being evaluated as to the rate per acre required to give the control that fenac and sinbar give. All 4 compounds are pre-emergence herbicides and have very little value as post-emergence compounds.

It is absolutely essential to keep the plant sugarcane as free of all weeds and grasses, including johnsongrass seedlings, as possible. In order to do this an application of one of the long residual herbicides should be made immediately after the sugarcane has been planted and covered in the fall and another application in late winter or early spring before weeds and grasses emerge.

The pre-emergence chemicals that are now in the market will do a very good job in controlling weeds and grasses in plant sugarcane if they are used as suggested by the Cooperative Extension Service. Some areas, and even some blocks of sugarcane, have a higher infestation of johnsongrass seed in the soil than other blocks. Some seedlings and some plants growing from rhizomes may escape the treatment in plant sugarcane. These plants become real problems in the stubble crops. An infestation of johnsongrass varies from one end of a block to the other end and from one block to another. This makes evaluation of chemical herbicides very difficult, especially as to the correct rate per acre and the time of application.

STUBBLE SUGARCANE

Stubble sugarcane in Louisiana is showing greater infestation of weeds and grasses each year because of poor management practices in the plant cane year. Plants that are showing in stubble sugarcane could be controlled in plant and stubble cane with the proper chemical or with the properly timed application of the herbicide. There are several plants, both broadleaf weeds and grasses, that now appear in stubble sugarcane which might be placed in the hard to kill category. Some of these plants are: Raoul or itchgrass, aster, Vaseygrass, black nightshade, Brachiaria, purslane, brown top panicum, and wild gourd.

CONTROL OF JOHNSONGRASS AND OTHER WEEDS AND GRASSES IN STUBBLE SUGARCANE

The use of T.C.A., dalapon, and silvex in different combinations continues to give some control of johnsongrass, other grasses, and broadleaf weeds in stubble sugarcane. These materials are limited in their scope of control but are the only weapons that are labeled for use in Louisiana sugarcane for the type of control needed. Some visual injury to sugarcane may be noticed in the early growing season where dalapon is used, but data collected over a number of years have shown that the sugarcane recovers and is higher in yield in both tons of sugarcane and sugar per acre than the untreated check. Some varieties are more tolerant to dalapon than other varieties grown in Louisiana.

In 1969, a new chemical, the sodium salt of methyl sulfanilylcarbamate - Asulam or Asulox - was tested and showed promise in controlling johnsongrass growing from rhizomes in sugarcane. The use-rate, or double the amount required for controlling johnsongrass in stubble sugarcane, was not injurious to the yield of sugarcane in several experiments conducted since 1970, whether applied by ground sprayer or airplane.

Asulox is effective in killing most grasses that have wide and extensive leaf area but has little or no effect on most fine or narrow leaf grasses, such as bermudagrass. Asulox is not effective in killing most broadleaf weeds that occur in sugarcane and should be mixed with silvex or a broadleaf-weed herbicide. Mixtures of Asulox, dalapon and silvex in the same tank have given good results for complete weed control when applied after April 15.

Early applications of TCA, TCA plus dalapon and silvex, or dalapon plus silvex aid materially in killing and suppressing johnsongrass so that good stands of stubble cane can be established. A later application of Asulox, or Asulox and dalapon, will kill most of the grass so the cane can grow.

In almost all comparisons made, the use of Asulox increased the tons of sugarcane and the pounds of sugar per acre over the check and the plantation practice.

The rather consistent increase in tonnage and the increase in pounds of sugar per acre in these comparisons eliminate the possibility of phytotoxic conditions from the use of the herbicides.

A SIMPLE AND RAPID METHOD TO DETERMINE MOISTURE AND FIBER IN CANE

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ABSTRACT

In our variety development program as well as in our commercial maturity control, hundreds of fiber analyses and still more of moisture in section 8-10 have to be performed throughout a season. Both of these procedures take time and are relatively tedious to accomplish, specially the slicing of cane for moisture determination. We have developed at CIASA a new method for both of these analyses using a carpenter's saw. The original idea was thought of by Senen Viego in Guatemala. The procedure is fast and simple, and the shredded cane dries much more rapidly than the slices. Many analyses with figures of comparison with the normal procedures are given in the moisture determination, as well as the detailed procedure for both methods.

INTRODUCTION

The price of liquidation of the Mexican sugar on a standard base quality is 1.52 Mexican pesos per kg (some 0.05 - 1/2 American cents per pound), of which 50% goes to the farmer and the other half to the manufacturer, not considering the farmer's benefits for molasses, alcohol, and sometimes bagasse, and manufacturer's premiums for refining and differentials. The law protects the farmer with an 8.2% minimum rendment, and certain factories have special agreements with the local associations guaranteeing higher recoveries. Thus, the farmer is only interested in producing as much cane as possible, and the manufacturer in recovering as much sugar as possible out of that cane. This situation becomes more significant when wages and other operating expenses increase in a non-proportional way with cane yields and factory rendments, and most of all price of sugar.

In order to receive as much sugar in cane as possible - practically all sugar companies carry, at their own expense, maturity or ripening programs ranging from the simple hand-refractometer observations to the more elaborated juice analysis and moisture determination in cane (1). We feel that this control is important in our case, for in our own Organization in this 1973/74 crop an increase of 0.1% in our rendment would have meant an additional income of nearly 6 million Mexican pesos (400,000 American dollars) for the 3,900,000 long tons of cane ground.

The expenses involved in these ripening programs are significant in many instances, including wages of unionized personnel working as sampling and grinding crews, clerical assistance, analysts, material, and equipment, such as vehicles, field tools, scales, grinding utensils, and laboratory accessories. On the other hand, there is a limit as to the number of analyses that can be made during the regular working hours. This is why these programs are generally started several weeks prior to the crop, and continued until the last stage of the grinding season. We usually run as many as 15,000 complete juice analyses and over 4,000 of the more elaborate moisture, fiber, and pol-ratios per season in our 5 sugar mills.

Our maturity control programs are usually revised every year with our field staff in each operation. We have introduced certain modifications tendint to either, increase our efficiency or cut down expenses without jeopardizing this efficiency. Last year I picked up an idea from Senen Viego in Guatemala, when he mentioned to me that perhaps a carpenter's saw could be used in obtaining cane material for complete analyses. I returned to Mexico with this idea on my mind; however, it was not until the second stage of the 1973/74 crop, when we were able at CIASA (Compania Industrial Azucarera, S.A.) to start the trials. We hope to substitute the method for the large and expensive 18-inch, 3-roller sampling mill, the hammer mill or shredder, the bagasse press, and the blender.

THE EQUIPMENT

Utilizing factory surplus and non-usable material from a field derrick, we built at CIASA a very simple unit, more or less similar to a small carpenter's saw. A wooden structure supporting on its lower panel a 1-1/2 HP triphasic electric motir with a 4-inch diameter pulley, driving a soft-wood combination circular saw modified from a 2-mm blade width to a 3-1/2 mm one mounted on a 3-1/2 inch diameter pulley. The 2-cm teeth were also triangularly sharpened, and had the somewhat zig-zagged disposition straightened out. All these modifications were the results of trial-

and-error operations. The finely shredded sample was primarily collected on a rectangular tray held inclined by pressure to one side of the tin funnel under the saw. The bulk of the material, not contained by the inclined tray, fell on a larger tray located loosely on the lower panel under the saw.

MATERIALS AND METHODS

The sugarcane samples were mainly collected in our 80-acre seed propagation station at CIASA, though some samples came from nearby commercial fields. Sampling was done as usual (2), but the stalks for fiber determination were cut shorter in order to facilitate manipulation of the cane when driving it through the circular saw. A sample consisted of some 6 to 12 stalks (depending on stubble tillering) making some 18 to 36 short pieces. An experienced operator driving these sections of cane through the saw would not consume over 1 to 2 minutes. However, the transversally driven 8-10 sections of cane stalks for moisture determinations take a little longer.

For the moisture determination technique instead, of slicing the 8-10 section internodes, as is usually done (1), they are transversally driven through the circular saw in such a way that the sample collected was not in the form of sliced pieces, but in a finely shredded material containing the whole cane. Practically all the internode is used, with an attempt not to get to near the differentiated anatomic section of the node. In a normal 8-10 section one can easily collect a 50-g sample, which is the amount we use. The material obtained is well mixed and transferred immediately to a tared small perforated tray some 7 x 7 inches, where it is weighed and placed in a conventional oven for drying to constant weight. We do not go above 85 C. in this process. Moisture is determined by weight difference as in the slice method. One can also save this dried sample for further analysis.

In the fiber determination the sections of the cane stalks mentioned earlier are driven longitudinally through the saw, trying to drive them as centrally as possible. In this manner one collects a longitudinal sample representative of approximately 1 cm of the central part of the cane stalk from rind to rind, which is compatible to one obtained through the conventional methods. The amount of finely shredded cane, which is much larger in volume than in the moisture test, is collected in both the lateral and lower trays. The 2 samples are well mixed and divided into 2 samples. A 100-g sample is immediately transferred to a tared tray, weighed and dried to constant weight as in the case of the case of the 8-10 sections. The other sample, enough to obtain the necessary juice is placed by portions in a hand pressure strainer (we used a common vegetable strainer), and juice is obtained for brix determination. We did not have available one of the precision refractometers, so we used a hand refractometer making the necessary temperature corrections. Having determined loss of water and total solids, we proceeded to calculate fiber as in the suggested LSU method (3). With the juice obtained by straining the shredded material, pol can be directly determined by the gravimetric or volumetric Spencer method (4).

We made over 150 analyses of the 8-10 sections and compared them with the regular slice procedure developed by Burr & Moir in Hawaii. In order to have a good base of comparison, the material was taken from the same internode, half of which was sliced and the other sawed. In certain cases we were unable to complete the 50 g, so we used as much as we could obtain.

For the fiber determination we were not able to run as many samples as we would have liked, for we needed the analytic help from the factory laboratory which is relatively busy at that time of the year. However, we did run over 50 analyses and compared them with the method used in our mill laboratory (5).

For all these tests we utilized most of our commercial varieties and as many others as possible, trying to use canes with different characteristics, which we assumed could have certain influence when using the sawing process. For example, fiber content and quality, density, sugar content, rind hardness, wax bloom, pithness, etc. Out of the 15 varieties used in these analyses, 6 are commercial canes grown in this region for many years, especially POJ 36, CP 34-116, and B 4364, which make up nearly 90% of our varietal census. The rest of the varieties, which are grown in restricted patches, were Mex 54-261, Mex 56-18, and Mex 54-81. Six experimental canes were included, which were selected for their specific characteristics. For example, CP 52-43, a nonflowering high density cane, L 60-25, a freely arrowing, early high sugar and high fiber variety.

RESULTS

In respect to the moisture determinations, the new method gave results comparable to the standard slice method. We ran into operational difficulties the first 2 days, so we did not

include these 10 analyses in our general average. Also, we eliminated the 12 analyses in which badly pithed cane was used. Consequently, the general average for both methods was taken from the rest of the normal analyses.

During the initial stage we thought that the high-moisture canes would give a rather significant difference between the 2 methods, but in the long run they only differed by 0.02%.

Badly pithed cane is not suitable for our moisture determination, not only because the results are not reliable, but also because it is rather difficult to obtain a uniform shredded material. Badly pithed cane is also not suitable for the conventional slice method. However, when the cane is driven longitudinally through the saw, pithiness does not seriously affect the fiber results.

We did not find any significant difference in the varieties we used; however, the operators mentioned that ITAV 57-197, and B 4363 were very easily handled in the moisture determination. These 2 varieties have a rather hard rind as their compatible characteristic. Again, in the slice method there are varieties more easily sliced than others.

Results obtained from the fiber analyses are presented in Table 1. For all samples tested, the differences between the new saw method and the mill-laboratory were small, ranging only from 0.02 to 0.38.

Table 1. Results of fiber analyses made with the standard mill-laboratory method and the saw method.

1974	Variety	Cycle and age	% fiber		
			Saw method	Mill-lab method	Diff.
04-22	B 4363	Stubble 10	18.16	18.01	0.15
22	POJ 36*	Stubble 12	19.41	19.11	0.30
23	B 4362	Plant 7	15.68	15.31	0.37
23	CP 34-116*	Stubble 11	20.15	19.77	0.38
23	Mex 55-261	Stubble 12	17.59	17.28	0.31
24	Gloria 52	Stubble 11	17.95	17.62	0.33
30	ITAV 57-197	Plant 10	16.15	16.01	0.14
05-06	Pappaloapam	Stubble 14	16.32	16.20	0.12
06	Mex 56-18	Stubble 11	16.86	16.61	0.25
07	Gloria 55	Stubble 11	18.42	18.29	0.13
22	Pepe Cuca	Stubble 12	16.29	16.27	0.02
22	B 4363	Stubble 10	17.87	17.72	0.15
23	Mex 55-261	Stubble 13	17.88	17.71	0.17
27	CP 60-1*	Plant 12	20.22	19.98	0.24
27	B 4363	Stubble 10	18.05	17.91	0.14
30	CP 52-43	Stubble 13	15.83	15.61	0.22
30	L 60-25	Stubble 13	19.68	19.49	0.19

*Badly pithed cane

At the end of April we modified our blade width and increased the speed of the saw. This did not have a significant bearing on the moisture determination, but considering the figures, it had some influence in the fiber test. Nevertheless, we preferred the wider sample with the wider blade.

CONCLUSIONS

The equipment is very simple and inexpensive and could be used in a comparative way in our maturity and variety test programs. Under our conditions we are able to increase the number of moisture determinations by 5 times, and the fiber analyses by as high as 20 times. If a large drying oven were available, an even larger number of analyses could be accomplished in an 8-hr day.

The modifications of the saw consisted mainly of increasing the plate width, sharpening and straightening the saw teeth, and increasing the revolving speed.

We hope that in the future only one operation will be necessary to prepare the sample for moisture, fiber, and pol in juice. We are now conducting tests comparing the moisture in the 8-10 section with the moisture in the whole finely shredded cane.

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SUGARCANE TOPS FOR CATTLE FEED^{1/}

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ABSTRACT

Sugarcane tops from cane variety Cl 49-200 were dehydrated and pelleted. Two types of pellets were manufactured; one contained 5% molasses and a second contained 5% molasses and 3% milk by-product. Both types of pellets were fed free-choice to steers on St. Augustinegrass pasture in a 226-day feeding trial. Weight gain and carcass grade of steers consuming 8.5 lb/head daily of pellets with molasses equalled that of steers on pasture only. Steers consuming 9.9 lb/head daily of pellets with milk by-product gained 9% faster and had carcasses of equal grade to steers on pasture only. Steers fed a snapped-corn-citrus-pulp-cottonseed-meal supplement at a level equal to cane-top pellet intake gained 70% faster and their carcasses were 2/3 of a grade higher than steers on pasture only. Results indicate that cane-top pellets would be useful in a grazing program as a pasture extended when forage growth is limiting. In a 121-day feedlot trial, finishing rations containing 0 (control), 17, 34, and 51% cane-top pellets with molasses were fed to heavy steers. Steers fed the 17% pellet ration were as efficient in converting feed to gain and gained 4% faster than steers fed the control ration. There was a progressive reduction in gains and feed efficiency by steers fed rations with 34 and 51% pellets. Cane-top pellet level in the finishing ration had little influence on carcass grade. Results suggest that cane-top pellets would be an excellent substitute for other standard roughage feedstuffs such as cottonseed hulls.

INTRODUCTION

Sugarcane tops are a major waste product of the 250,000 acres of sugarcane harvested annually in south Florida. Field data showed that approximately 2 tons of cane-top dry matter per acre was salvageable from variety Cl 41-223 following the annual harvest (10). These data were from cane burned preharvest and estimated to yield 35 tons of millable cane per acre.

In Florida and other cane producing regions of the world, there has been a scarcity of locally produced feeds for cattle. Beef production systems demand supplemental feeding during low production periods to maximize pasture utilization due to seasonal pasture forage growth. The tropical sugarcane areas also experience a deficiency of feedstuffs for formulating finishing rations to fatten cattle. Also, roughage type feeds for finishing rations in the feedlot areas of the U. S. have been in good demand.

Previous data showed that chopped green cane tops were readily consumed by steers, and moderate weight gains were exhibited when cane tops were supplemented with cottonseed meal (10). Brazilian data (5) showed a similar response by cattle fed fresh and ensiled cane tops.

The purpose of this study was to gain information on the feeding value of dehydrated-pelleted sugarcane tops when fed as a supplement to steers on pasture and when fed as a major component in finishing rations for steers fed in confinement.

MATERIALS AND METHODS

The sugarcane tops used in this study were from variety Cl 49-200. The cane was burned before harvest to eliminate dead leaves and other trash. Tops were manually cut from the cane stalk at approximately 6 to 12 inches below the first hard joint. Tops were gathered with a field forage chopper 4 to 5 days after the cane harvest. During processing, tops were passed through a chopper, preheater (conditioner), triple-pass dehydrator, hammer mill, and pellet mill, respectively. Five percent molasses, fortified with urea to 60% crude protein equivalent, was blended into the dehydrated tops immediately before pelleting. In one batch of pellets 3% milk by-product, consisting of a mixture of waste products from milk processing, cheese trimmings, etc., was also blended into the cane tops before pelleting. All pellets were made at the same time and stored in an enclosed barn.

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Laboratory studies. Cane top samples were obtained at various stages of processing and analyzed to determine dry matter, crude protein, crude fiber, ether extract, ash, and nitrogen free extract (1). Roselawn St. Augustinegrass samples obtained during February thru May were also analyzed. In vitro digestible organic matter (DOM) was determined for cane-top and St. Augustinegrass samples using a modification of the Tilly and Terry method (7).

Digestion trial. A total collection digestion trial was conducted to determine the in vivo DOM of cane-top pellets containing 5% urea fortified molasses and 3% milk by-product. Three yearling Hereford steers were used. The preliminary period was 10 days and the collection period was 5 days. Organic matter analyses were made according to methods of A.O.A.C. (1).

Pasture feeding trial. Forty four steers were randomly divided into 4 treatment groups by weight and breeding. Steers were a mixture of straight-bred Angus and Hereford, and crossbreds of these 2 breeds with Brahman. Each group was placed on a 4-acre Roselawn St. Augustinegrass pasture on February 8, 1972. Treatment groups were: (a) pasture only, (b) pasture + concentrate supplement, (c) pasture + cane-top pellets, and (d) pasture + cane-top pellets containing 3% milk by-product. Group 1 contained 8 steers and groups 2, 3, and 4 contained 12 steers each. Formulation of the concentrate supplement was: ground snapped corn, 36.5%; dried citrus pulp, 36.5%; cottonseed meal, 18.0%; molasses, 7.5%; mineral mix, 1.5%; and vitamin A (30,000 USP units/g), 0.16%.

Supplements were fed once daily. Cane-top pellets were offered free-choice and the concentrate mix was fed at a rate equal to the treatment in which steers consumed the greater amount of pellets. After 28 days on test the intake of cane-top pellets by steers in groups 3 and 4 was at a level such that an adequate protein intake was questionable. At this time these groups were fed 1 lb of cottonseed meal per steer daily. All steers had access to mineral mix free-choice.

Steers were weighed every 28 days, and treatment groups were systemically rotated between pastures after each weigh period to minimize any effect of pasture difference. Steers were visually appraised as to condition at the beginning and end of the study. Weight gain and supplement intake was recorded. Adjusted final weight was calculated to give a 57% dress on chilled carcass weight. Steers were shipped 160 miles to Plant City, Florida, for slaughter after a 226 day feeding period, and carcass information was collected.

Experimental data were analyzed statistically using analysis of variance of a completely randomized design. Orthogonal contrasts were used to partition treatment variation into individual components.

Drylot finishing trial. Eighty crossbred steers of Angus, Hereford, and Brahman breeding (more than 50% British) were randomly divided by weight into 8 lots of 10 steers each. Two lots each were fed one of 4 finishing rations containing 0, 17, 34, and 51% cane top pellets. Formulation and proximate analysis data for the experimental rations are presented in Table 1. Additions of cane-top pellets replaced equal weights of snapped corn and citrus pulp in the control ration (0%). Rations were fed ad libitum along with 2 lb of pangolagrass hay per head daily.

Steers were fed 122 days in concrete floored pens. Animal performance data collected included daily feed intake and live weight gain. Feed conversion was calculated from these data. Animals were assigned a slaughter grade at the beginning and end of the trial. After completing the feeding trial, steers were shipped 195 miles to Center Hill, Florida for slaughter, and carcass information was collected. Adjusted final weight was calculated to give a 57% dress on chilled carcass weight.

Experimental data were analyzed statistically using analysis of variance of a completely randomized design. Orthogonal contrast were used to analyze response trends due to increasing cane-top pellet level in the finishing ration.

Table 1. Formulation and laboratory analysis of finishing rations containing various levels of sugarcane-top pellets.

Item	% cane-top pellets			
	0	17	34	51
Formulation				
Cane-top pellets, lb	0	170	340	510
Ground snapped corn, lb	365	280	195	110
Dried citrus pulp, lb	365	280	195	110
Cottonseed meal, lb	180	180	180	180
Molasses, lb	75	75	75	75
Mineral mix, lb ^{1/}	15	15	15	15
Vitamin A g ^{2/}	76	76	76	76
Analysis ^{3/}				
Dry matter, %	87.7	87.8	88.3	88.7
Crude protein, %	16.6	16.2	14.9	14.2
Crude fiber, %	10.9	15.6	19.2	22.5
Ether extract, %	3.7	2.8	2.6	1.9
Ash, %	7.1	7.3	6.9	7.2
NFE, %	61.7	58.2	56.4	54.2

^{1/} Mineral mixture contained 40% defluorinated rock phosphate, 22.5% dicalcium phosphate, 20.0% iodized salt, 1.0% red oxide of iron, 3.2% copper sulfate, 0.15% cobalt sulfate, 7.5% citrus meal, and 5.85% molasses.

^{2/} Contains 30,000 USP units Vitamin A/g.

^{3/} Crude protein, crude fiber, ether extract, ash, and NFE values calculated to a moisture-free basis.

RESULTS AND DISCUSSION

Laboratory studies. Proximate analysis and *in vitro* DOM of cane-top and St. Augustinegrass samples are presented in Table 2. Differences between the analytical data for fresh and dehydrated tops were minor, indicating that dehydration did not affect the nutritive value of cane tops. With additions of molasses and milk by-product both protein and *in vitro* DOM progressively increased, reflecting the protein content and digestibility of these additives.

Table 2. Proximate analysis and *in vitro* digestible organic matter (DOM) of sugarcane tops and St. Augustinegrass. ^{1/}

	Sugarcane tops (%)				St.
	Fresh	Dehydrated	Pellets ^{2/}	Pellets + milk by-prod. ^{2/}	Augustine grass
Proximate analysis ^{3/}					
Dry matter	39.7	91.0	95.4	94.3	21.4
Crude protein	5.8	6.4	7.2	8.8	16.0
Crude fiber	33.9	33.9	31.3	30.1	26.3
Ether extract	1.5	1.4	1.6	1.6	2.4
Ash	6.2	5.5	6.9	6.6	9.3
NFE	52.7	52.8	52.9	52.8	46.0
In vitro DOM	36.2	34.9	38.2	42.0	54.5

^{1/} Number of samples analyzed proximate analysis and *in vitro* DOM, respectively, were: fresh tops, 18 and 8; dehydrated tops, 7 and 5; pellets, 9 and 5; pellets + milk by-product, 5 and 5; St. Augustinegrass, 36 and 16.

^{2/} Both types of pellets contain 5% urea-molasses.

^{3/} Values for crude protein, crude fiber, ether extract, ash, NFE, and *in vitro* DOM were calculated to a moisture-free basis.

The in vitro DOM of St. Augustine grass was much higher than that of cane tops. In vivo DOM approximates the total digestible nutrient (TDN) value of a feed. The in vitro DOM value for St. Augustinegrass was 5 to 8 percentage points below the TDN value determined for this grass grown during a similar period of the year (3). Likewise, in vitro DOM values of cane tops were 10 percentage points below TDN values reported for green tops and cane top silage (9).

Digestion trial. The in vivo DOM value of cane-top pellets with molasses and milk by-product was 45.4%. This was 4 percentage points above the in vitro DOM value. This confirms the data on St. Augustinegrass, which indicated that in vitro analysis underestimates the DOM of feeds for cattle. The lower in vivo DOM values in comparison with TDN values reported by Morrison (9) may be due to pelleting. Pelleting was shown to reduce dry matter digestibility of other forages 10 to 15% (6, 8).

Pasture feeding trial. Animal performance and carcass information data are shown in Table 3. Weight gains and carcass measurements of steers fed both types of cane-top pellets were similar to steers on pasture only. These data show that supplementation of steers on pasture with pellets will not adversely influence performance. Since the laboratory- and digestion-trial data showed that the energy value of cane-top pellets was inferior to St. Augustinegrass pasture, the total dry matter intake of steers supplemented with pellets must have exceeded that of steers on pasture alone. It is generally accepted that dry matter intake of a forage, when fed alone, is increased by pelleting (2). It should also be considered that steers fed pellets consumed 1 lb of cottonseed meal per head daily. Steers supplemented with pellets containing milk by-product gained slightly faster than steers fed pellets without this ingredient but the difference was not significant ($P > .05$). Average daily intake of pellets with milk by-product was slightly greater than pellets without this additive.

Table 3. Average animal performance and carcass data obtained to evaluate sugarcane-top pellets as a supplement to steers finished on pasture.

Item	Pasture only	Concentrate mix	Cane-top pellets	Cane-top pellets + milk by-product
Number of steers	8	12	12	12
Initial weight, lb	564	555	571	564
Final live weight, lb ^{1/}	805	967	812	830
Weight gain, lb	241	412	241	266
Avg. daily gain, lb	1.07	1.82	1.07	1.18
Supplement intake, lb/day	---	9.89	8.51	9.81
Cottonseed meal, lb/day	---	---	1.00	1.00
Condition score ^{2/}				
Initial	8.2	7.9	7.8	7.8
Final	9.1	10.5	9.1	9.4
Increase	0.9	2.6	1.3	1.6
Dressing percent ^{3/}	51.9	57.0	51.5	54.2
Chilled carcass, wt., lb ^{4/}	459	551	463	473
Carcass grade ^{2/}	8.3	10.8	8.5	8.8
Fat over eye, in.	0.26	0.47	0.25	0.32
Ribeye area, sq. in.	9.8	10.6	9.7	10.1
Estimated yield, % ^{5/}	51.7	49.8	51.7	51.2
Fat color ^{6/}	2.4	2.8	2.3	2.7

^{1/}Final live weight calculated to a 57% dress on a chilled carcass weight basis.

^{2/}Low, medium, and high standard = 6, 7, and 8; and low, medium, and high good = 9, 10, and 11; respectively.

^{3/}Dressing percent = chilled carcass weight ÷ actual final feedlot weight.

^{4/}Chilled carcass weight = warm carcass weight - 2% shrink.

^{5/}Estimated yield = percent of carcass in boneless, closely trimmed, retail cuts of round, loin, rib, and chuck.

^{6/}Fat color; 1 = white, 2 = cream, 3 = slightly yellow, and 4 = very yellow.

Performance and carcass quality measurements of steers fed concentrate supplement were greatly superior to that of steers in the other 3 treatments. These differences were significantly different ($P < .01$) except for fat color, which was not significant ($P > .05$).

The results of this trial indicate that cane-top pellets could be best utilized in a grazing program as a pasture extender. Pellets would be particularly useful during the winter months for feeding light weight steers to maintain gains and stocking rate or for heavy steers where standard to good carcasses are the objective. It also appears that cane-top pellets could be valuable as a supplement to steers grazing ryegrass pasture.

Drylot finishing trial. Feedlot performance data and carcass measurements are presented in Table 4. Several interesting trends were observed and their significance are notated in the table.

Table 4. Feedlot performance and carcass measurements of steers fed various levels of sugarcane-top pellets in finishing rations.

Item	% cane-top pellets				Trend	
	0	17	34	51	Linear	Quadratic
Number of steers	20	20	20	20		
Initial weight, lb	883	884	884	884		
Final live weight, lb <u>1/</u>	1128	1139	1094	1056		
Weight gain, lb	245	255	210	172	**	NS
Avg. daily gain, lb	2.02	2.11	1.74	1.42	**	NS
Daily dry matter intake, lb	24.7	25.2	26.6	26.6	NS	NS
Dry matter/ lb. gain, lb	12.3	12.0	15.3	18.7	**	*
Condition score <u>2/</u>						
Initial	7.3	7.3	7.2	7.5		
Final	10.4	10.6	10.3	10.2	NS	NS
Dressing percent <u>3/</u>	57.2	57.1	56.3	54.2	**	*
Chilled carcass weight, lb	642	649	624	602	**	NS
Carcass grade <u>2/</u>	10.9	10.7	10.8	10.6	NS	NS
Fat over eye, in.	0.55	0.46	0.47	0.42	NS	NS
Rib eye area, sq. in.	10.5	11.2	10.7	10.4	NS	*
Estimated yield, % <u>5/</u>	48.6	49.7	49.5	49.8	**	NS

1/Final live weight calculated to a 57% dress on a chilled carcass weight basis.

2/Low, medium, and high standard = 6, 7, and 8; and low, medium, and high good = 9, 10, and 11; respectively.

3/Dressing percent = chilled carcass weight ÷ actual final feedlot weight.

4/Chilled carcass weight = warm carcass weight = 2% shrink.

5/Estimated yield = percent of carcass in boneless, closely trimmed, retail cuts of round, loin, rib, and chuck.

* $P < .05$

** $P < .01$

NS $P > .05$

Generally, the results showed that the performance and carcasses of steers fed the 17% pellet ration equalled that of steers fed the control ration. Additional increases of cane-top pellets to the 34% and 51% levels adversely affected both animal performance in drylot and carcass measurements. Trends observed with increasing pellet levels above 17% of the ration were linear decreases in rate of gain, dry matter conversion to gain, dressing percent, and chilled carcass weight.

A curvilinear relationship was observed between ribeye area and cane-top pellet level in the ration. Steers fed the 17% pellet ration had a larger ribeye area than steers fed the control ration, but ribeye area decreased when pellet concentration increased to the 34% and 51% levels. Carcasses from steers fed the control ration had the lowest estimated yield, while carcasses of steers fed rations with cane-top pellets had similar yields. Cane-top pellet level had little effect on final condition score, carcass grade, or fat thickness over the ribeye.

Dry matter (DM) intake progressively increased with increasing amounts of cane-top pellets in the finishing ration up to the 34% level. This trend was not statistically significant; however, DM intake was determined by lot (average of 10 steers) and there were only 2 observations per treatment. DM intake was previously shown to be directly influenced by pelletization (2) and inversely affected by the available energy content of the ration (4). The latter factor probably had the greater influence on DM intake in this trial considering the low available energy content of cane-top pellets.

The results of this trial demonstrated that sugarcane-top pellets can be effectively utilized in steer finishing rations up to 17% level. This feedstuff appears to be an excellent substitute for other standard roughages such as cottonseed hulls.

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PAPERS PRESENTED AT 1974 MEETING OF FLORIDA DIVISION

October 24, 1974

DEVELOPMENT OF MECHANICAL SUGARCANE PLANTER AT
SUGAR CANE GROWERS COOPERATIVE OF FLORIDA

Larry G. Fowler and Fritz Stein, Jr.
Sugar Cane Growers Cooperative of Florida
Belle Glade, Florida

ABSTRACT

As hand labor becomes more scarce each year, it is imperative that the Florida sugarcane growers focus their attention on developing a means to plant sugarcane mechanically and thus reduce the dependence on hand labor in the planting operation. Sugar Cane Growers Cooperative of Florida has recently designed and constructed a prototype mechanical sugarcane planter and are conducting field tests with this unit at the present time. Approximately 150 acres of cane have been planted by this mechanical method thus far with the cane planted seeming to germinate satisfactorily; however, not enough cane has been planted with the unit to make a comparison with hand-dropped cane.

INTRODUCTION

During the past few years some advances have been made in the Florida sugar industry to reduce the amount of hand labor required and the rising costs of planting sugarcane. This has come about by the various mechanical aid designs which have been incorporated into out planting wagons.

Since cane planting is such a great investment for the grower in his future sugarcane production, total mechanization of the planting procedure is probably one of the most important and critical areas in which mechanization can be applied.

As hand labor becomes more scarce each year, it is imperative that we focus our attention on developing a mechanical means or method where by hand labor can be reduced and we can continue to maintain the same proficiency as is presently attained in planting sugarcane by hand.

We at Sugar Cane Growers Cooperative have been working toward mechanization of the planting procedure. We now have in use one prototype mechanical cane planter and have been experimenting with this unit for the past few weeks. Moreover, we are also working with a method of hauling and transferring seed cane which provides maximum use of both the cane planter and the seed transporting equipment.

MATERIALS AND METHODS

The mechanical cane planter incorporates a series of conveyors and levelers to accomplish the same end result of planting cane while eliminating the need for hand labor for dropping and increasing planting production.

This cane planter is a hydraulically-operated tractor-drawn rubber-tired 2-row unit which is operated by one operator located at the front of the machine and behind the drawing tractor. This unit consists of 3 main parts, namely, the storage bin, distribution conveyors, and the dropping conveyors.

The storage bin has a capacity of about 460 cu ft and is used for storing the cane seed. The bottom of the bin is constructed as a slat type conveyor and is operated hydraulically for moving the cane seed pieces to the front of the bin and into the hoppers of the distribution conveyors. Should the cane pieces be tangled, packed high, or tight, in the bin, a hydraulically operated rake pushes the top of the seed pile into the hoppers of the distribution conveyors.

The cane seed pieces in the distribution conveyors are moved upward and leveled by the steep angle aided by the rotating leveler. To impart a gently leveling action to the seed pieces, the leveler device is composed of a pipe-type shaft with 3 rubber-belting-type vanes attached.

As the seed cane pieces are discharged over the end of the distribution conveyor, they slide down a smooth flat surfaced chute into the dropping conveyor.

The dropping conveyor is essentially a continuous single chain with lugs attached for positive movement of the seed pieces. To insure proper metering of the seed pieces on the conveyor, a leveler is used to control the depth of the seed. This leveler is also constructed of rubber-type vanes to avoid damage to the seed pieces.

After the seed has been metered on the dropping conveyor, it is discharged directly into the furrow in a continuous manner. To insure that the seed pieces fall directly into the furrow, rubber flaps are attached at the discharge end of the dropping belt and hang down into the planting furrow to form a direct chute into the furrow.

The distribution conveyors are located at the front of the planter perpendicular to the line of travel of the unit while the dropping conveyors are located along each side of the planter on 10-foot centers. By this configuration, 2 rows of seed cane are planted simultaneously, with the seed being dropped into every other furrow.

The tracks of the drawing tractor as well as the wheels of the cane planter move on top of the beds and straddle the middle furrow.

The seed hauling unit used in this system is a rubber-tired, tractor-drawn unit which has 2 individual seed compartments attached. Each box or compartment is equipped with 2 hydraulic cylinders and is hinged at the upper left side. As the hydraulic cylinders are actuated, the compartments tip at the hinge point to dump the load at an elevation of about 10 feet.

Each compartment of the wagon has a capacity of about 225 cu ft for a total volume of about 450 cu ft.

RESULTS AND DISCUSSION

Several different varieties of cane have been planted with the mechanical planter thus far. These varieties are as follows: CL 41-223, CP 57-603, and CP 63-588.

The seed cane used for planting was loaded by mechanical harvesters and varied to a great degree in cleanliness due to the recumbency of stalks and seed-cane variety. Seed cane which was erect and could be mechanically topped produced the least trashy seed pieces.

It was obvious from the first field tests that the cleaner the seed the better the operation of the planter. This was borne out further by the fact that the Caterpillar D4D tractor towing the planter could be operated in 2nd gear with fairly clean seed but had to be operated in 1st gear with extremely trashy seed.

The time required to plant four 1/4 mile rows of cane was approximately 10 min, and this time varied depending on the cleanliness of the seed. The maximum acreage planted with this prototype unit was 12 acres in an 8-hr day with the maximum planting rate timed at 2 acres per hour.

Time required to transfer the seed from the seed transporting wagon into the planter was approximately 2-1/2 min.

From operational observations of the planter, certain advantages were evident by the tractor and planter unit riding on the beds rather than in the furrows to be planted. By riding on the beds, should chokes occur in the planter, then the operator can back the unit to fill skips on one side or both sides. Should cane be planted too skippy, then rows can be replanted by moving the machine over the same path without disturbing the cane already planted. Also, one row can be planted by stopping one side of the planter and moving over the beds without disturbing the seed already planted in adjacent rows.

One of the main advantages of this planting system is that the maximum efficiency can be obtained from the planter unit since it never leaves the planting fields, and likewise, maximum efficiency can be obtained from the seed hauling unit since this unit is used exclusively for moving seed from the seed-cane field to the planter unit.

CONCLUSIONS

Although we have only planted about 150 acres with this mechanical planter, it appears that this unit has much potential. It is further felt that with the experience and data obtained from this prototype machine a very efficient and high capacity mechanical planter can be produced.

The cane planted thus far with the mechanical planter seems to germinate satisfactorily; however, at this time not enough cane has been planted with the unit to make a comparison with hand-dropped cane.

USE OF COMPUTERS AT SUGAR CANE GROWERS COOPERATIVE OF FLORIDA

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ABSTRACT

The enormous problems of offshore and domestic payroll, inventory control, expense accounting, and cane delivery and analysis in the sugar industry can be greatly minimized by the use of the current day computer system, when it has been carefully and efficiently programmed. It is the purpose of this paper to give a general idea of the areas in which the computer is being used at Sugar Cane Growers Cooperative of Florida to solve the problems of rapid data capture, tight controls, minimization of human error, and the reporting of fast and accurate information.

INTRODUCTION

During the construction and following 2 crop seasons outside service bureaus were used to prepare construction reports and offshore payrolls. Also, small bookkeeping machines were purchased to prepare the cane delivery reports, domestic payrolls, inventory movement, and do the general accounting applications.

After the third year of operations, it became evident that there was a growing need for in-house data processing capabilities. At this point, unit-record data-processing equipment was leased. It consisted of 3 key punches, an 80-column card sorter, and a small unit record-accounting machine. After 3 more years the small unit record-accounting machine was replaced by a larger one with more capacity. By this time more and more applications were taken off of the manual system and put on the data processing equipment. This used up the capabilities of the new unit record equipment in one year, and it was at this point that we leased our first computer system. It consisted of 4 key punches, an 80-column card sorter, and a third generation computer card system. The next 3 years saw the company expanding and more applications were put on the computer.

Then in July of 1972 the old card computer system was replaced by our present fourth generation disk computer system.

MATERIALS AND EQUIPMENT

Our present system is a fourth generation computer with 16,000 positions of core storage. It has the capacity of 9 one-half million characters of on-line disk storage. The line printer operates at the speed of 200 lines per minute printing up to 132 characters per line. The 96-column card reader reads up to 500 cards per minute. In addition to the computer we have four 96-column card data recorders which are used for data entry.

METHODS

Data are captured by punching the required information into 96-column cards on the data recorders. Next the cards are taken to the computer and fed into the card reader, which reads the coded data and records it on the disk by magnetizing spots on the disk surface much in the same manner as a tape recorder works. Once we have the data on the disk, we can work at electronic speed and our only noticeable limitations are the speeds of our input and output devices. The data on the disk now could be sorted, matched, or merged with other data to create meaningful data files. Now we can manipulate these files through the use of programs which have been stored in the memory of the computer to produce a payroll check, or an inventory transaction report, or any other desired results on the printer.

PROCEDURES

The following set of flow charts show how data are entered into the system and used to produce domestic payrolls, inventory controls, expense accounting, offshore payrolls, and cane delivery and analysis reports.

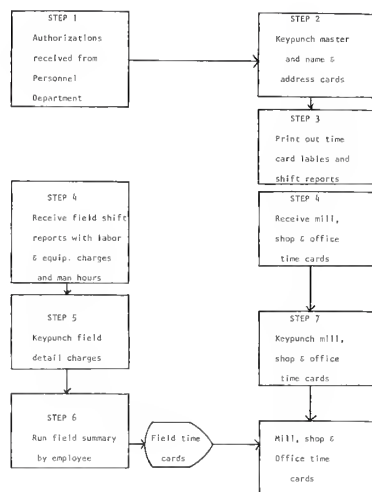


Fig. 1. Steps 1-7 in use of computers in preparation of domestic payrolls.

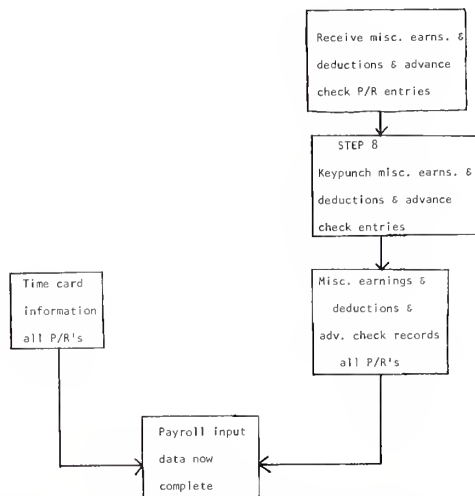


Fig. 2. Step 8 in use of computers in preparation of domestic payrolls.

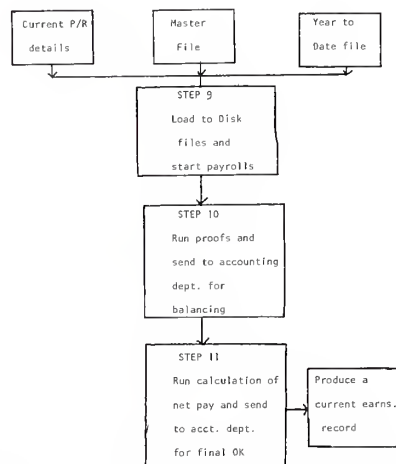


Fig. 3. Steps 9-11 in use of computers in preparation of domestic payrolls.

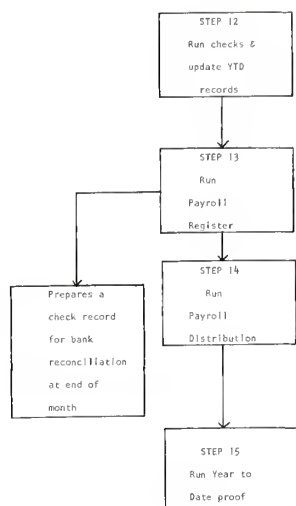


Fig. 4. Steps 12-15 in use of computers in preparation of domestic payrolls.

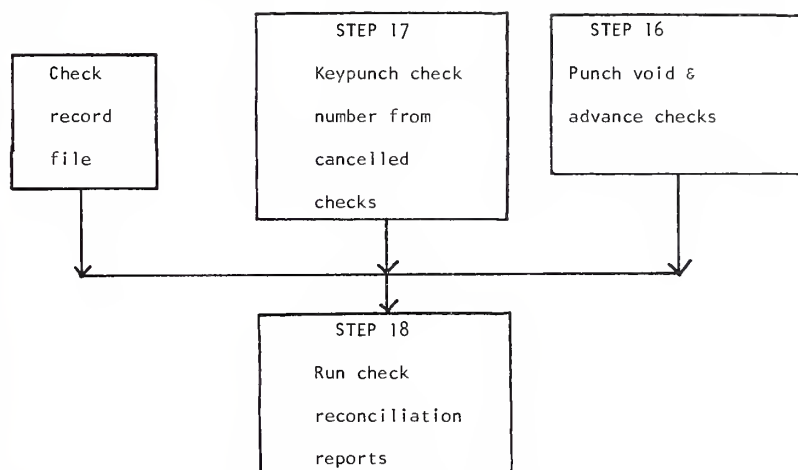


Fig. 5. Steps 16-18 in use of computers in preparation of domestic payrolls.

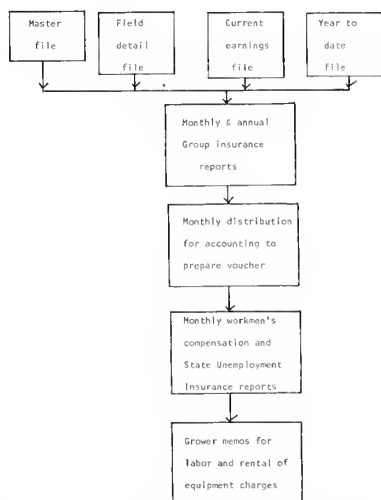


Fig. 6. Additional use of computers to collect payroll data.

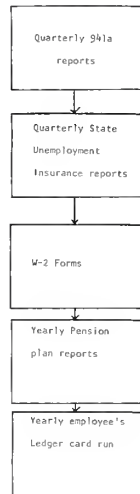


Fig. 7. Additional use of computers to collect payroll data.

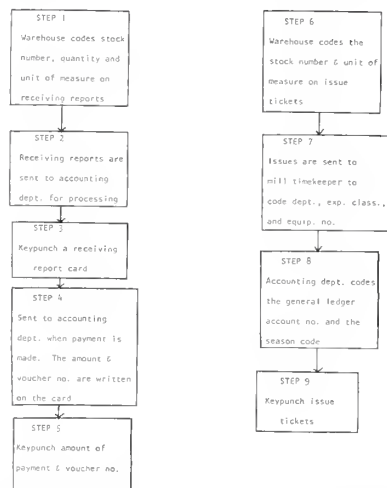


Fig. 8. Steps 1-9 in use of computers for inventory control.

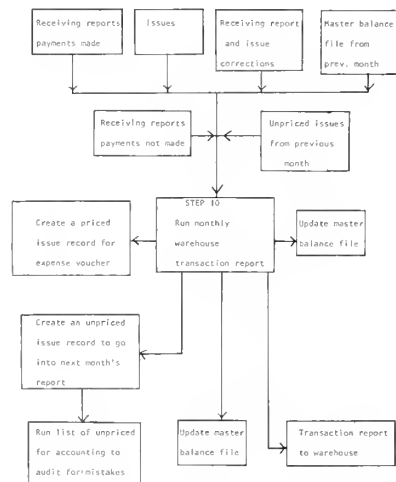


Fig. 9. Step 10 in use of computers for inventory control.

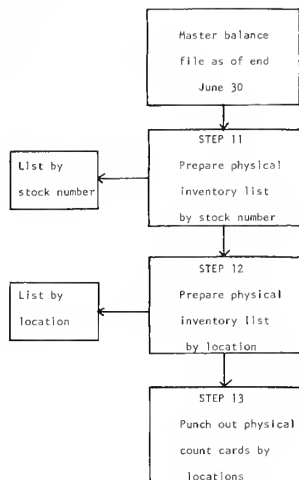


Fig. 10. Steps 11-13 in use of computers for inventory control.

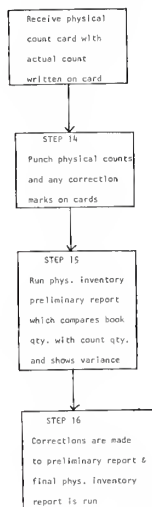


Fig. 11. Steps 14-16 in use of computers for inventory control.

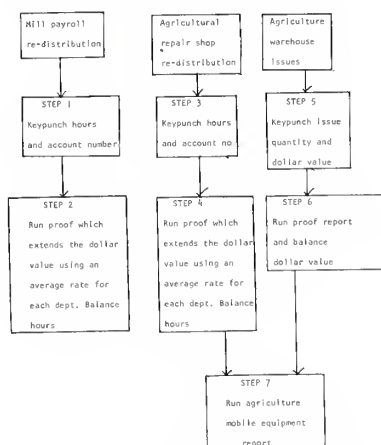


Fig. 12. Steps 1-7 in use of computers in expense accounting.

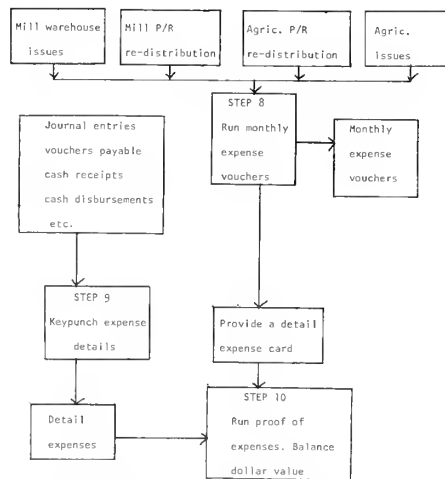


Fig. 13. Steps 8-10 in use of computers in expense accounting.

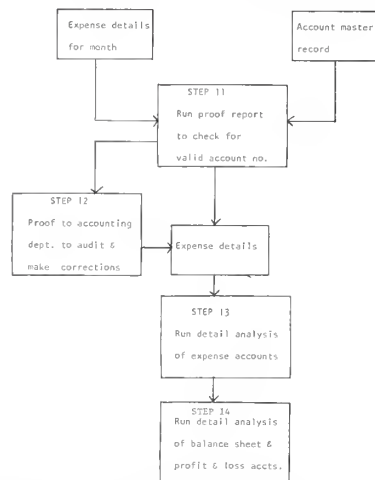


Fig. 14. Steps 11-14 in use of computers in expense accounting.



Fig. 15. Steps 15-19 in use of computers in expense accounting.

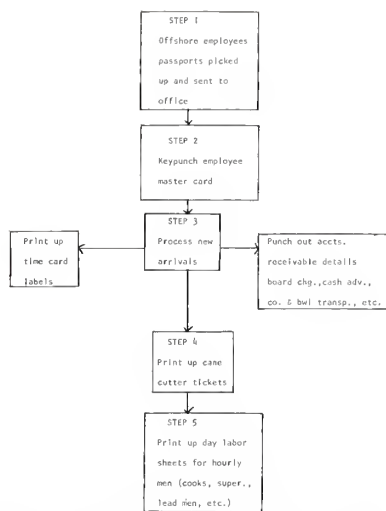


Fig. 16. Steps 1-5 in use of computers in preparation of offshore payroll.

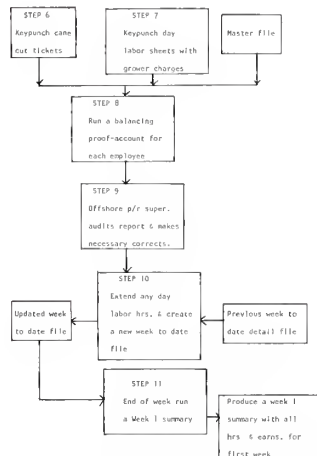


Fig. 17. Steps 6-11 in use of computers in preparation of offshore payroll.

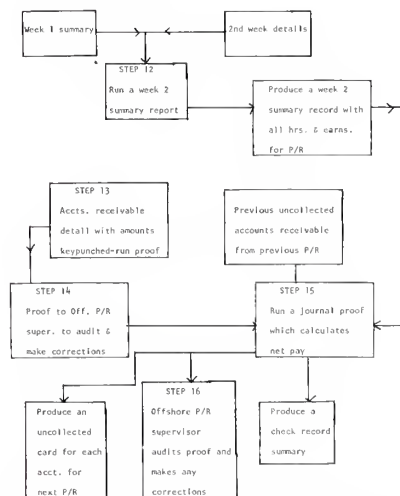


Fig. 18. Steps 12-16 in use of computers in preparation of offshore payroll.

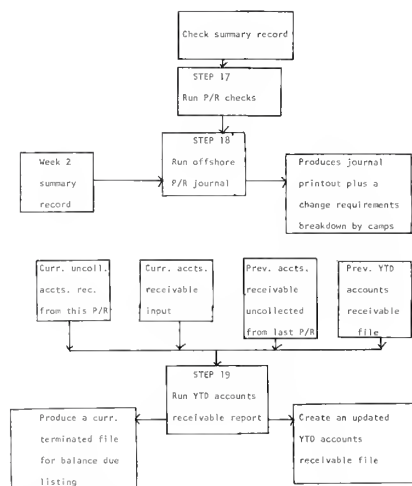


Fig. 19. Steps 17-19 in use of computers in preparation of offshore payroll.

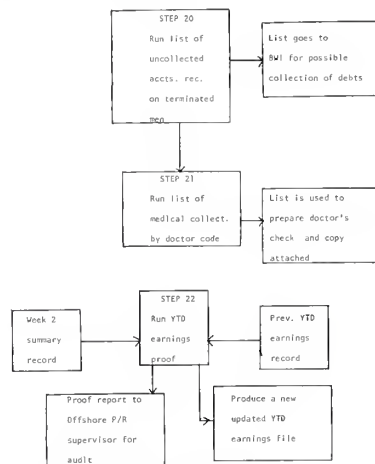


Fig. 20. Steps 20-22 in use of computers in preparation of offshore payroll.

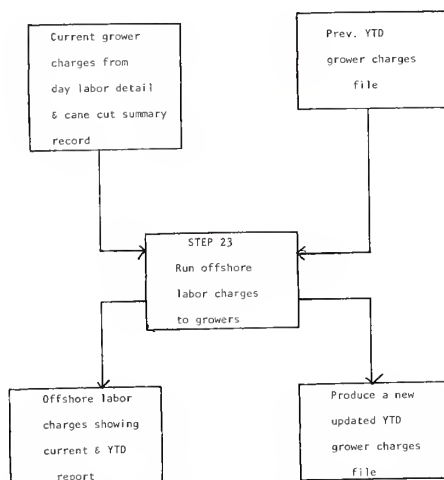


Fig. 21. Step 23 in use of computers in preparation of offshore payroll.

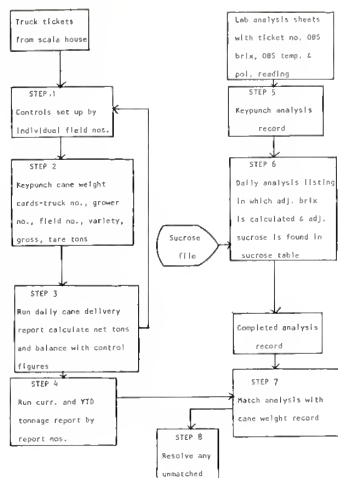


Fig. 22. Steps 1-8 in use of computers in cane delivery.

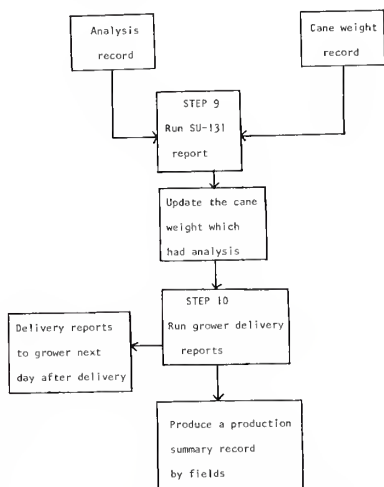


Fig. 23. Steps 9-10 in use of computers in cane delivery.

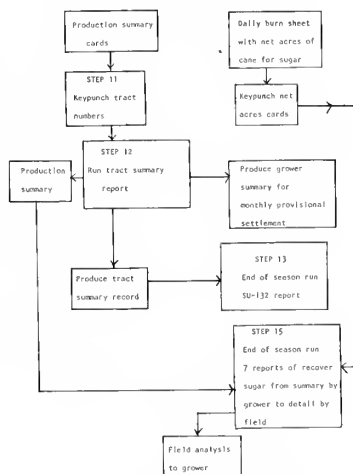


Fig. 24. Steps 11-15 in use of computers in cane delivery.

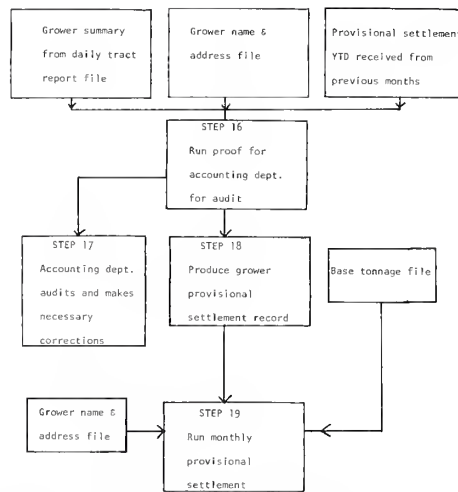


Fig. 25. Steps 16-19 in use of computers in cane delivery.

STATISTICS

	Number of Programs	Core Storage Required To Execute	Number of Program Steps Required	Number of Reports Produced
Domestic payroll	74	464,264	9,524	48
Inventory control	31	156,514	1,606	18
Offshore payroll	84	448,016	7,851	45
Cane del. & analysis	77	582,386	12,926	55
Expense accounting	<u>86</u>	<u>573,841</u>	<u>9,024</u>	<u>64</u>
	352	2,225,003	40,931	230

The data processing staff consists of 2 keypunch operators, one secretary/computer operator, one programmer/computer operator, and one supervisor/programmer. During the crop season we put on 2 more full time data-recorder operators and 2 part time data-recorder operators.

RESULTS AND DISCUSSION

The flow charts had to be condensed due to their length, and it should be stated that only the necessary data was punched into the cards entering into the system. By eliminating the punching and verifying of unnecessary data, we save a great deal of time. By running balancing and editing reports, we catch all the incorrect data before it gets into the system. By verifying what has been punched, the system itself cannot generate incorrect data. Not all jobs can be done efficiently on a computer. They may be done faster or at less cost on a manual system thereby leaving the computer to do the bigger, more costly, and more time-consuming jobs.

This system has emerged over the past 10 years and has been constantly re-systemized to bring together all applications. The system automatically generates fast, accurate, and very meaningful reports such as general ledger and trial balances, budget reporting, mill and agriculture equipment cost reports, and very important detail field analysis on recoverable sugar.

If the computer system is carefully and efficiently programmed and has the cooperation of the user departments which it serves, it can and will be one of the most valuable tools in the sugar industry.

1974 I.S.S.C.T. MEETING IN SOUTH AFRICA

Stanley L. Hooks
Okeelanta Sugar Division
Gulf and Western Food Products
South Bay, Florida

No formal paper was presented on this subject. Mr. Hooks presented a slide program of his trip to the I.S.S.C.T. meeting in South Africa. His program included side trips to the sugar growing areas of Brazil, a visit to Argentina and a visit to the world famous Kruger National Park in South Africa.

A SHORT-BILLET, CONTINUOUS-FEED SUGARCANE PLANTER

W. Stewart Boots
Agbay, Incorporated
South Bay, Florida

Mechanizing the planting of sugarcane has become a goal for the sugar industry which is probably second only to mechanical harvesting in importance. Historically, planting sugarcane has been a tedious and labor consuming job which has not lent itself to mechanization, with the exception of using continuous loaders with hand-cut cane, or mechanical harvesters to load various types of planting aides.

The goal of this project was to build a planter which would automatically plant 2 rows of short-billet cane, either hand cut and loaded with a continuous loader or cut and loaded with a mechanical harvester.

Some of the design parameters chosen to guide the development are as follows:

1. Keeping the mechanism as simple as possible.
2. Making the operating technique as uncomplicated as possible.
3. Planting 2 rows, with the planter traveling in the furrows.
4. Minimizing the expense of the prime mover by having the planter drawn by wheel tractor.
5. Using a billet length of nominally 20 to 22".
6. Carrying sufficient cane to plant 2 rows of 1/2 mile length under normal conditions.
7. Dropping the cane with sufficiently good orientation to minimize covering or cultivation problems.
8. Keeping damage to the seed pieces to a minimum.

The development work on this planter began in June of 1974, following some preliminary experimental work prior to that date. The work has been carried out in conjunction with one of the Glades area cooperatives, which is presently using a number of the planters on a daily basis.

The planter in its present form basically consists of a hopper or body, 14' long, 5' high, and 6' wide, which is divided longitudinally into 2 compartments by an inverted vee divider which runs the length of the body. At the outer extremity of the hopper, on each side, there is a hydraulically powered drag chain which runs in a trough formed by the vertical outside wall of the hopper and the 45° slope of the divider on the inside edge of the trough.

The chain conveyor has flights welded to it in a staggered pattern which help to improve the spacing of the billets in the furrow. The spacing between 2 flights on the same side of the chain is 30".

The center divider is mounted on bearings near the apex of the vee and is oscillated continuously back-and-forth by a hydraulic cylinder and self-oscillating valve mounted underneath the divider. The divider oscillates with a total travel of 4" measured at the lower corners. The purpose of the oscillating divider is to help maintain a flow of cane to the chains when operating with trashy cane, and with clean cane which will tend to bridge.

The cane discharges to the rear where it falls into the chutes, which guide it into the furrow.

The body is mounted to a chassis with tandem axles and single wheels in order to avoid deforming the furrow excessively.

The hydraulic source to power the wagon is the tractor auxiliary hydraulic system. The overall height of the wagon is 9'-3", and the wheel track is 5'. Practical planting speeds range from 1 mph for very trashy cane to 5 mph for quite clean cane.

Operating the planter is quite simple because the only operating adjustment is the selection of the proper gear for the tractor. The chains have no speed control which requires the tractor to change ground speed in order to adjust the planting rate. However, once this speed is determined for the condition of the seed, no further adjustment is normally required.

Since the planting season began late in August, these wagons have planted over 500 acres, which will allow some preliminary conclusions to be drawn concerning their performance.

Utilizing a mechanical harvester as a seed source allows the wagons to plant at speeds from 3 to 5 mph, with minimal feed interruption with the varieties tried to date.

Hand-cut continuous-loader cane is less satisfactory as a seed source because of leafy trash in the load impeding the flow of cane to the chains; however, well-stripped and piled hand-cut seed is quite comparable to harvester cane in planting properties.

Problems yet to be overcome include feed difficulties with trashy continuous-loader cane, minor skips, non-uniform feed in harvester cane, and minor damage to the seed piece.

However, if the seed source supplies clean cane to the planter and field walkers are used to even out short skips and light spots, the wagon is usable with the equipment and personnel available to the South Florida sugar mills.

THE CHANGE IN REGULATIONS CONCERNING OFF-SHORE WORKERS

George Sorn
Florida Fruit and Vegetable Association
Orlando, Florida

Although no formal paper was presented, Mr. George Sorn discussed the major changes in regulations and procedures concerning offshore workers, namely, 1.) Method by which the determination of the minimum wages of sugarcane workers was made for the 1974-75 crop season, 2.) Record keeping and recording of actual time worked in the field, and 3.) Sunday work by off-shore workers.

NAPIERGRASS ERADICATION: A COOPERATIVE EFFORT

Harry H. Samol
Florida Sugar Cane League, Inc.
Clewiston, Florida 33440

ABSTRACT

Napiergrass is one problem we cannot afford to put up with. It drains our pocketbook in many ways: by reducing tons of cane per acre, by slowing harvest operations, by increasing trash content, and by outgrowing all but the very best control efforts. The total loss of revenue due to this problem has not been estimated, but would surely be impressive. The economics of the Glades area depends on sugar, and, as we have seen, Napiergrass is not conducive to good sugarcane production. It is therefore vitally important that all growers and involved agencies establish programs and supporting budgets that are sufficient to eradicate Napiergrass from their lands. If this is done, our program will succeed. It is your responsibility as cane growers to lead the way, for it is you who will benefit most.

INTRODUCTION

Napiergrass, Pennisetum purpureum, is one of the most serious weed problems associated with sugarcane culture in South Florida. This fact has been well documented and is generally recognized throughout the industry.

Let us review some of the problems presented by Napiergrass infestations, the control methods currently recommended, and an outline of the Florida Sugar Cane League's program which is aimed at eliminating Napiergrass as a major problem in our area.

PROBLEMS POSED BY NAPIERGRASS

One problem posed by Napiergrass is its unsightliness. Sugarcane fields and adjoining headlands, ditchbanks, and roadsides denote good management when they are free of Napiergrass and other weed problems. But the problems go far beyond this when sugar production is affected.

J. R. Orsenigo, Plant Physiologist with the Agricultural Research and Education Center in Belle Glade, presented a paper (1) to this group at the first Florida Division meeting in 1970, which showed substantial reductions in sugarcane production where Napiergrass was established in the field. Production was highest where there were few Napiergrass stools and lowest in fields with heavy infestations.

If we in Florida are going to increase our sugar production, the major portion of that increase will come from producing more sugar per acre. Some additional acreage will be grown, but good agricultural land is scarce. One way to increase sugar per acre is to eliminate Napiergrass and other weeds from our fields.

Orsenigo (1) also showed a large increase in the number of Napiergrass stools present between time of close-in and harvest. This point cannot be overlooked from a control standpoint, for here we have seed germination after controls have normally been applied. And the seeds would have come mainly from Napiergrass outside the field, as they are carried by the wind for some distance. This points out one of the main reasons for controlling Napiergrass in non-crop areas, i.e., ditchbanks, roadsides, levees, etc. Even the best control effort will meet with only limited success if uncontrolled areas nearby provide seed for reinfestation.

Napiergrass can also be a factor during controlled field burning. Infestations with a cane field will have more green leaf material than the surrounding cane. This can result in a poor burn in heavily infested fields.

If Napiergrass growing adjacent to a cane field has been damaged by a frost, it will burn readily and could cause a fire jump into another field. And muck fires along ditchbanks can sometimes be traced to Napiergrass stools where the dry stalks have burned to the ground and ignited the organic soil.

Besides being unattractive, a fire hazard, and reducing sugarcane production, Napiergrass is causing problems where mechanical harvesters are being used. When fields of sugarcane are cut by hand the cutters can leave the Napiergrass standing, for later removal. The harvesters, however, are not as agile or selective.

If a harvester is cutting seed cane and the operator can not avoid a stool of Napiergrass, it will be cut, loaded, and planted along with the cane. And with the coming of the mechanical planter there will be little opportunity to remove the Napiergrass before it is planted.

This problem is further complicated when the extractor fans on the harvester blow Napiergrass pieces across the field. This will only help to spread the problem over a larger area.

A further objection to Napiergrass is the added expense of harvesting fields that have heavy infestations, but, (a) it will take longer for hand cutters to finish the field; (b) the continuous loader will have to operate slower; and (c) if a mechanical harvester is being used it will operate slower if it tries to leave the Napiergrass or will harvest it along with the cane, thus increasing the trash content. Each of these factors is costly. Can you afford them?

One further problem is the apparent increase in rat damage to sugarcane in fields with Napiergrass infestations. The very dense growth provides excellent harborage for field rodents and probably provides nesting material. Some foliar feeding insects which damage sugarcane can also be found on Napiergrass, which may harbor growing insect populations before they move into the cane fields.

CURRENTLY RECOMMENDED CONTROL METHODS

Flooding of fallow fields during the spring or summer is a well-established practice with many Florida sugarcane growers. Observations have shown that in-field control of Napiergrass is enhanced by a good flood program. This, however, does little to reduce the problem in surrounding non-crop areas.

Mowing or chopping when done on a regular schedule or combined with chemical treatments are extremely useful operations along ditches, roadsides, headlands, etc. The rising costs of fuel may be a factor in determining the amount of mowing to be done. However, mowing is still one of the best controls available when done on a regular basis.

Grazing of farm animals on levees and other non-crop areas can effectively control Napiergrass when it is small and has no woody stems. Though this practice has very limited application, it should not be overlooked.

Chemical treatment is widely accepted as a good and practical control method. However, when used in the absence of sound cultural practices, it too will have limited success.

CURRENT RECOMMENDATIONS FOR CHEMICAL CONTROL OF NAPIERGRASS

Non-Crop Areas - Soil Sterilants

Karmex 80W and Telvar 80W at 50 lb/acre have been shown to be superior to both Sinbar and Hyvar X, used at slightly lower rates. These treatments of Karmex and Telvar provided 87 and 93% control, respectively, 30 months after treatment. The Napiergrass had been run down with a "devil-catcher" and was treated before the regrowth was waist-high.

Non-Crop Areas - Foliar Sprays

Roundup is the best foliar spray that has been tested against Napiergrass. Though it is a high-priced herbicide, it gives good control. The recommended rate is 1 gal per acre in 20 to 30 gal of water. Timely retreatment will be necessary when regrowth occurs. Chopping or mowing is not recommended prior to treatment as this compound is translocated throughout the growing plant, even to the roots.

Dowpon gives good control if retreatments are made. At the rate of 15 lb/acre, 4 applications at 4-8 week intervals provided 68% control, 23 months after treatment.

Retreatment is essential with foliar sprays.

Sugarcane In-Field

Dowpon at 7 to 10 lb/100 gal water is the only herbicide recommended for in-field use as a spot spray. Generally, 2 applications will be required, although 3 applications will give better control. Repeated applications have 2 principal advantages: (a) increased response from plants sprayed earlier, and (b) treatment of shoots which emerged after the earlier application.

FLORIDA SUGAR CANE LEAGUE NAPIERGRASS ERADICATION PROGRAM

We can all agree that it is very costly to cultivate Napiergrass along with sugarcane. We can agree that we have some valuable tools to be used in control programs. When then do we still have a serious problem, and what can be done about it?

Napiergrass is still a serious problem because it has not been attacked from all fronts. Some areas where it grows are neglected entirely, others receive only occasional attention, while still other areas are properly managed and well controlled. And this is the focal point of the FSCL eradication program. The prime objective of this program is to eliminate Napiergrass as a major problem in sugarcane. This may seem to be a monumental task, but the underlying theory is not complicated.

We are asking everyone: sugarcane growers, municipalities, railroad companies, highway departments, darinage districts, etc., to do the very best job possible on their lands. Napiergrass is a costly problem to everyone, and everyone will benefit if we can eradicate or at least drastically reduce our infestations through a truly cooperative effort.

If you spend the money necessary and set up a good Napiergrass control program while your neighbors do not, you will have limited success. This same situation exists where Napiergrass is uncontrolled along railroads, highways, levees, and other lands adjacent to sugarcane fields.

Contacts have already been made with public and private agencies whose rights-of-way extend into sugarcane growing areas. All agencies contacted have expressed concern over the Napiergrass problem and have shown a willingness to cooperate in an area-wide eradication effort.

Some growers are already doing a good job of controlling Napiergrass. But all growers must be willing to do a little extra if we are to succeed. By redoubling our own control efforts we would not only be improving control, reducing losses, and setting an example, we would also be showing our concern and determination to eliminate the problems associated with Napiergrass. The amount of true, meaningful cooperation that we can expect from people outside the industry may well be related to the amount of true, meaningful cooperation we give each other.

The FSCL is acting as coordinator of this program. We will keep you informed of its problems and progress. If at any time you have questions or problems related to your Napiergrass control program, contact the League office.

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PAPERS PRESENTED AT 1974 MEETING OF LOUISIANA DIVISION

February 7-8, 1974

THE OUTLOOK FOR FINANCING SUGARCANE PRODUCERS

F. Vernon Wright
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The problem in economic forecasting today is the speed at which everything is changing. The symptoms of Future Shock are already with us, even down on the farm. As the author of that book said, the question is whether we can survive all the changes coming at us so fast.

Just look at what has happened in the cattle business lately. In the middle of 1973 housewives were so mad about beef prices they organized national boycotts. A few weeks later they were trying to buy meat at any price. But by fall the ranchers and feedlots were losing money on steers and heifers. Now the prices have gone back up, perhaps temporarily. Cattlemen aren't sure which way to turn next. The increase in feed-grain prices started the uproar in the cattle business and then the effects spread into the hog and poultry business and even the cheese business.

We operate in an extremely tightly-knit society today. There was a time when you could throw a rock into the economic waters and cause a ripple. Today you're likely to cause a tidal wave.

THE NEW CATALYST

The export market is the new catalyst in agriculture. It primarily affects feed grains, rice, and wheat. Sugar is not directly affected because we import sugar instead of exporting it. But you never know how one end of our trade policy is going to affect another end.

Today we are learning that the energy shortage is going to affect practically everything we do. Your sugarcane industry got an early taste of the problem when your mills were threatened with a cutback in natural gas. That's the kind of uncertainty we face in the coming year . . . or years. The uncertainty will have a tremendous impact on the kind of financing you get in the future.

That brings me down to the theme of my talk - the outlook for financing sugarcane producers. Like everything else these days, the answer comes in both good news and bad news.

CREDIT FUND AVAILABLE

The good news first: We are confident there will be sufficient money to finance all segments of the sugarcane business in the coming year - even in the great volume your industry will need. Speaking at least for the Production Credit system, we think we have escaped the threat of tight money such as we had in 1969.

Now the bad news. Interest rates will continue to be relatively high. They might drop a little in the second or third quarter of 1974, but I am afraid the nation is stuck with the current levels for a while. The high rates - short term, intermediate term and long term - are so entrenched in our economy that it almost takes a depression to turn them around significantly.

Fortunately I don't think we have to worry about a depression this year. We are possibly in for heavy unemployment - maybe even 6%. We probably face cutbacks in tourism . . . the recreational vehicle business . . . and the airline business.

However industry is currently planning a 15% increase in capital spending on new plants and equipment in 1974. And if the energy shortage causes problems in some industries, it will create opportunities for many other enterprises - such as the home entertainment and bicycle businesses. This period of adaptation could maintain strong pressures on the supply of money.

HEAVY GOVERNMENT BORROWING

In simpler times, the Federal Reserve Board could tighten up money to fight inflation or loosen up money to stir up the economy. But in 1974 we face the threat of both 6% inflation and 6% unemployment. The Federal Reserve Board will have to tip toe through that kind of economy. Its day by day decisions will affect agriculture as well as other industries.

The federal government - and local governments - continue to apply pressure on the money market with their heavy borrowing. The administration budget calls for an \$8 billion deficit. That means more government competition in the bond market and probably high interest rates for everybody, including agriculture.

These and many more fluctuating factors will influence the rates that sugarcane producers will pay for money this year and next year. The cost of agricultural credit increased steadily throughout 1973. In the beginning of 1973, we were able to sell our bonds for 5.8%. By September the rate reached an all time high of 9.75%. Then it dropped back to 8.6% in December. The increase covered both short and intermediate term issues.

Agriculture, of course, is not accustomed to such interest rates as we had last year. Since the Production Credit system was established 40 years ago, farmers and ranchers have been able to obtain relatively low cost operating money through cooperative borrowing. Even in 1973 our PCAs were able to beat the prime rate most of the year. While banks around the nation charged their prime customers 10%, we were making loans to members at the 8 1/2% to 10% level.

The South Louisiana PCA did not raise its rate to 9% until last November. It is now holding the rate down to that level by operating on a spread of just one-half of one percent.

SETTING THE PACE

I mention these PCA figures because credit cooperatives are the biggest single lenders in the agriculture production business and they influence the rate for all agricultural lenders.

The Production Credit system is part of the national Farm Credit System, which also includes the Federal Land Banks and the Banks for Cooperatives. We are supervised by an agency of the federal government - just like commercial banks are. However we are owned by farmers and ranchers and we do not use any government money whatsoever. The government does not even guarantee our bonds.

The Land Banks specialize in rural real estate financing and the Banks for Cooperatives make loans to agricultural cooperatives, including quite a few sugarcane co-ops. The Production Credit system specializes in financing farm and ranch production. We provide one- to seven year loans for everything from livestock to seed, fertilizer, living expenses, equipment, educational expenses, cars and trucks. However we can lend only to farmers and ranchers who buy stock and become members of the PCAs. They buy stock in proportion to the amount of money they want to borrow.

Within the production credit system we have 12 Federal Intermediate Credit Banks and 435 PCAs, each of which is an autonomous unit with its own board of directors. The banks sell bonds to investors and loan money to the PCAs. The PCAs do the actual lending to farmers and ranchers.

\$8 BILLION IN BONDS

Last year our 12 banks sold about \$8 billion worth of bonds to the investing public. We're able to sell these bonds at the most favorable rates because they are safe investments. PCA loan losses for the past 40 years have amounted to only one-tenth of one percent.

Our FICB in New Orleans supervises the 26 PCAs in Louisiana, Mississippi, and Alabama. These 26 associations loaned \$530 million in 1973. That was 19% more than the previous year. We expect to increase our lending another 18% this year, which would bring our 1974 total to about \$600 million.

In Louisiana we have four PCAs serving the sugarcane industry. They are the Baton Rouge PCA . . . the Opelousas PCA . . . the Alexandria PCA . . . and the South Louisiana PCA. If I talk mostly about the South Louisiana PCA today it is only because that association does nearly 90% of its business in sugarcane, more than any other association. There are more than 300,000 acres of sugarcane within the South Louisiana PCA territory.

AVERAGE LOAN: \$25,000

Leon Zeringue the South Louisiana PCA president - recalls that the level of sugarcane financing has increased from \$25 per acre in the 1940s to over \$100 per acre today. The average loan among his 500 members is now about \$25,000.

We expect that average to increase as you people continue converting from manual labor to sophisticated equipment, including planting equipment. This growing mechanization increases the need for additional capital. So do the constantly rising costs of operation. The new environmental regulations are increasing costs. So will the energy shortage. William Simon said recently that agriculture will get all of the fuel it needs, but he did not say how much it would cost you. You may become more concerned about the price than the availability if fuel keeps going up.

If consumers think food costs are increasing, they should look at the increases in farm production costs. We are trying to tell this cost story in some of our advertising and in the current issue of our farm credit magazine - Info III. The entire issue is devoted to food production costs - fuel, land, equipment, labor, and supplies. We hope it will help consumers understand some of the problems involved in raising sugarcane, rice, beef, and the other products that come off our farms and ranches. The magazine points out, for instance, that one sugarcane farmer has to operate and maintain 13 tractors, 2 high-clearance trucks, 2 crawlers, 2 tandem trucks, 3 pickups, one 1 1/2 ton truck, 4 cane loaders, 20 cane carts, and 3 cane harvesters.

UNPRECEDENTED BORROWING

All this machinery requires the kind of borrowing never before known in agriculture. We made loans to about 17,000 farmers and ranchers in our three states last year. The average size loan across the three states was \$26,000, but many of them ran well over \$100,000.

With that kind of credit floating around, everyone in agriculture is concerned about the effects of the energy shortage. Lenders, for instance, need some assurance that farmers can obtain - and afford - enough fertilizer to insure a good yield. They need assurance that a farmer can obtain and finance sufficient fuel to harvest his crop. And they need assurance that processors can obtain and can afford enough power to handle the crop after it is harvested. A breakdown anywhere along this chain can spell trouble for both farmers and their lenders.

But we are optimistic that the sugarcane industry will be able to provide these assurances. Your industry leaders have shown that they can tell their story effectively. They proved that last fall when they averted the cutback in natural gas deliveries to your mills. It indicated again that you have a strong, dynamic industry here in South Louisiana.

FIVE CREDIT FACTORS

When we consider loan applications, we look at five factors - integrity, financial position . . . repayment capacity, loan purpose and collateral. The sugarcane industry scores high in all of these.

But in the final analysis, we do not finance crops, machinery or an industry. We finance people - people who want to grow and who are willing to plan, budget and work to grow.

We have done business with your sugarcane producers for 40 years now, including some mighty tough years. Your people have shown that they can snap back from weather problems . . . governmental problems . . . shortages . . . cost-price squeezes . . . and numerous other problems. They have often turned adversity into growth. That's one reason we stuck it out again with so many of our members who ran into financial trouble during the flooding last spring.

We look upon ourselves as partners in your farming operations and we want to see our partners succeed. We will go the extra mile with them whenever we can do so without endangering the investments of other members.

Your record of growth insures a bright financing outlook for your industry. We believe that very strongly. And we're willing to back up that belief with millions of dollars in credit annually. We look forward to working with you for many more years.

Thank you.

CORE SAMPLING STUDIES - 1973

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ABSTRACT

Evaluation of cane quality for payment has become increasingly difficult with 100% mechanization of harvesting and the volume of extraneous material accompanying the cane. Recognizing the need for an improved cane sampling system, the authors initiated studies in the 1950's on core sampling and methods for processing the sample. These studies were subsequently discontinued due to sample bias associated with the vertical or parallel corer and problems in developing a satisfactory sample-processing scheme. With the recent availability of a commercial-scale inclined-tube core sampler and a heavy duty hydraulic press for sample processing, these studies were reinitiated in 1972. The late arrival of the press necessitated processing the core sample by multiple milling in the Farrel sample mill. The results were sufficiently encouraging to warrant a more intensive study during the current 1973 crop. These studies covered the areas of (a) press reproducibility, (b) accuracy of the press processing scheme as compared to the wet disintegrator method, (c) the press response to trash as green and dry leaves and the various soil types encountered in the cane belt, (d) variability among samples within a single cane consignment, and (e) the correlation of cane quality of a consignment by core-press sampling with that from factory-scale milling of the sampled consignment. These studies showed the hydraulic press to have a high degree of precision or reproducibility. Pol % cane by the press closely approximated that by the wet disintegrator method. The press was an excellent sensor of trash as indicated by a high degree of correlation between the trash and the fiber % cane. While there was a variation in cane quality among samples from the same consignment, there was no bias as to the sample location. There was good correlation between the cane quality of the core-press sample and that of the consignment subsequently milled in the Audubon Sugar Factory tandem. Based on these observations, it is recommended that full factory-scale studies be initiated in 1974 to determine such mechanical aspects as corer service factor, the sample volume which can be handled, personnel, and the equipment requirements and sample station layout.

INTRODUCTION

The Current System of Cane Quality Evaluation.

The general practice of washing cane in the carrier necessitates sampling the cane before it enters the mill - generally by mechanical grab from the consignment on the feeder table. The cane samples are analyzed for trash and for sample mill brix, pol, and purity. By means of the trash determination, delivered or gross cane is converted to net or trash-free cane. The grower's sample-mill inspections are factored to get his normal juice sucrose and purity. From the net tons and normal juice sucrose and purity factors, the grower's standard tons are calculated.

The grower's payment is then the product of his standard tons and the basic price per standard ton. The latter is the product of a sharing factor (which generally reflects the relationship between producing and processing costs) and the prevailing price for sugar.

The conversion of the sample mill analyses to normal juice quality is done by means of factors which relate the all-grower sample mill brix and pol to the factory normal juice brix and sucrose. These factors are then subsequently applied to the individual grower's sample mill analyses. These factors include the dilution compensation factor, which relates the sample mill brix to the undiluted crusher juice brix, and a dry milling factor relating the undiluted crusher juice brix to the factory normal juice brix. The factory normal juice sucrose is calculated from the mixed juice purity and the normal juice brix.

It is evident from the preceding that the conversion from the simple grower's crusher juice analyses (in the days of hand-cut cane) to sample mill inspections and trash corrections (following field mechanization) has led to an unwieldy system of questionable accuracy.

The Need for Improved Cane Quality Evaluation.

The need for developing a better method of cane sampling for payment is critical as a means of providing an incentive to the growers for delivering better quality cane to the factories. A major problem in Louisiana is that of cane quality as affected by intensive mechanization of field operations. Varietal test data from our experiment stations indicate that the sugar is in the standing cane. We are not getting the sugar in the bag, as evidenced by the factory

production reports. Actually, the 1970-73 average factory yield per net ton of cane is not significantly higher than the 1939-42 average. Additionally, cane quality poses a problem in factory capacity - particularly with wet field conditions. Maximum factory efficiency and capacity are essential if we are to maintain a degree of self-sufficiency in domestic raw sugar in light of the increasing price of the commodity on the world market.

A Review of Cane Sampling Studies in Louisiana.

During the 1950's, a comprehensive study covered problems of sampling sugarcane in Louisiana and alternative sampling schemes. The investigations included the variability of cane quality within a field plot and a commercial bundle of cane (7), the effect on sample precision and accuracy of the size of the sample (3), methods of sample removal (2,3), and different sample processing schemes (4,5). Probably the highlights of these studies were core sampling for sample removal and a comparison of sample processing schemes which included cold digestion, the wet disintegrator or cold water extraction method, a high extraction-severity sample mill, a screw press, and a locally fabricated vertical hydraulic press. Relative to core sampling, a bias in sample quality with sample location was associated with the simple horizontal or vertical core sampler - and the method of loading the cane in the conveyance. As for the sample processing studies, the wet disintegrator method was felt to be too time consuming and failed to adequately reflect the effect of field soil in the samples. A well designed sample mill or a screw press represented a considerable equipment investment and posed problems in standardizing sample processing schemes. While the hydraulic press offered a simple processing scheme, inadequate pressure (a result of the press design) resulted in poor reproducibility among replicate samples. On this note these investigations were discontinued.

The 1972 Studies (1).

With the availability of a commercial-scale inclined-tube core sampler, sample disintegrators, and a vertical hydraulic press capable of exerting mill-scale pressures on a large sample, the earlier sampling studies were reactivated. In these studies, an idealized cane-sampling system was defined to (a) remove the judgement factor in selecting and processing the sample, (b) standardize the sample procurement and processing equipment, (c) minimize personnel requirements, (d) divorce the system from the mill operations, (e) provide a sample representative of the quality of the material in the cane consignment, (f) reflect the effect of trash in general and field soil in particular on juice quality and quantity, (g) provide a measure of cane quality in terms of the estimated recoverable sugar in the cane, and (h) for the processor, contribute to the factory chemical control - and for the grower provide a means for evaluating variety and cultural practices.

The corer was the inclined-type, traversing the consignment at an angle, and equipped with a prebreaker to attrite the sample. Due to the late arrival of the hydraulic press, the core samples were processed on the hydraulically loaded Farrel sample mill with 4 passes through the mill.

The 1972 studies involved a comparison of the conventional and the core sampling system - and factors relating to each system. Correlations were developed between the juice quality from the core sample and the juice from the conventional sample milling, i.e., the sucrose sample. The variability among core samples from the same vehicle was investigated. Finally, correlations were developed between the cane quality as predicted by the conventional and the core-Farrel mill system and that determined by milling the whole consignment on the Audubon Sugar Factory milling tandem.

The core-Farrel mill system entailed removing 3 core samples (front, middle, and back) from the conveyance, blending the samples, subsampling, and processing the subsamples by multiple milling in the Farrel mill in order to simulate commercial-scale milling severity. When the consignment was to be milled at the Audubon Sugar Factory, the cane was transferred from the field cart to a truck and taken to the factory where it was transferred to the feeder table prior to milling. The conventional sampling system involved removing by mechanical grab a 100 lb trash sample and 3 sucrose samples of about 30 lb each from the feeder table. The sucrose samples were processed in the usual manner with one pass through the mill.

The investigation showed that the juice quality from the core-Farrel mill samples more closely approximated that of the factory crusher juice than that from the conventional sucrose sample. While there was a variability among core samples from the same consignment, there was no bias relative to the location of the sample in the load.

Both sampling systems gave about the same degree of correlation with the factory mill results, i.e., a correlation coefficient of about 0.85. However, the conventional sampling

scheme was highly idealized in that the procurement and processing of the trash and sucrose samples were closely supervised, and the normal juice quality was derived directly from the crusher juice with no moving average sample mill - normal juice factors. In a final series of studies, cored vehicles were sent directly to the feeder table of the factory where the corer was sited. There was negligible correlation between the cane quality as predicted from the core sample and that determined at the factory sample station. This was partly attributed to the practice of using running 6-day averages of the conversion factors. Thus the factors accumulated during a rainy spell will be applied to the cane during a subsequent dry period - until the initial factors finally wash out.

The core-Farrel mill system was an ideal juice quality sensor. However, it did not do so well in predicting the effect of trash. This appeared to be due to the fact that considerable field soil was washed into the juice with the multiple milling. A prime item of interest, then, was how well the hydraulic press would sense the trash - particularly the presence of field soil. This could not be confirmed during this series of tests.

A Proposed Core Sampling System.

Based on the 1972 studies, and some preliminary screening runs with the hydraulic press, the following core sampling scheme was hypothesized as a basis for the 1973 studies.

The core sampler is an 8-in. vertically inclined tube with saw-tooth edges which cuts through the cane consignment at an angle of about 45°. Upon retracting, a sample of 30 to 50 lb is ejected into a mulcher, which grinds the sample and discharges it into a container. The core sampler straddles the vehicle - cart or trailer. It is possible to take one or more samples from the conveyance. The number of samples will have to be determined. The diagonal travel of the corer has an advantage over the simple horizontal corer which travels in a parallel plane directly through the conveyance. At a diagonal, all sections of the cane stalks should be represented in the sample.

The core sample is blended and a 1 or 2 lb sub-sample is weighed and placed in a vertical hydraulic press. The sample is pressed, the juice collected, and the press residue or bagasse weighed. The juice is analyzed by refractometer for brix and by the usual dry lead method for pol. For the 1973 investigations, bagasse was analyzed by the conventional indirect method in which the sample is tested for moisture and pol, brix is calculated from the pol and the extracted juice purity, and fiber is determined by difference. For commercial-scale implementation it is proposed that moisture only in bagasse be determined. From the juice analyses and the bagasse moisture, the fiber, brix, and pol in bagasse would be calculated (6). This eliminates the time-consuming fiber determinations which are necessary for the indirect method noted above - and for the wet disintegrator (Waring blender type analysis). The validity of this proposal will have to be verified. The following information is then tabulated as direct cane data:

% cane: Pol
 Brix
 Fiber

From these data the theoretical recoverable sugar (TRS) is determined by means of an equation which assumes a standard milling extraction as a function of the fiber, the Winter-Carp theoretical retention, and a standard boiling house efficiency. The basic data given to the grower is his theoretical recoverable sugar.

If adopted on a state-wide basis, the sum of the theoretical recoverable sugar for all growers in the state is compared with the sum of the sugar produced in the state. From this a liquidation factor, F, is calculated.

This liquidation factor F times the grower's theoretical recoverable sugar gives his recoverable sugar. Obviously the sum of the all-grower recoverable sugar (as factored) must be equal to the sum of the sugar actually produced in the state.

The growers' payment is based on a percentage share of the recoverable sugar. This percentage would reflect the current share of the processing and growing costs - and would be no different from that which is currently calculated. Percentage sharing might be a single figure or - as in Puerto Rico - it may be higher for high quality cane and lower for low quality cane.

A pro-forma payment would be made on the basis of a certain percentage of the theoretical recoverable sugar.

AREAS OF INVESTIGATION

Hydraulic Press Reproducibility.

The objective of this test series was to determine the precision of the hydraulic press as an analytical tool. Individual core samples were thoroughly blended and subdivided into 3, 4, or 5 subsamples, and the subsamples were processed and analyzed individually to determine the reproducibility of the press and the analytical techniques.

Cane Quality by Different Sample Processing Techniques.

Again the core samples were blended and subsampled. The subsamples were processed in the hydraulic press, the Farrel sample mill, and by cold water digestion to determine the relative cane quality by the different processing schemes. The cold digestion was assumed to give the correct value.

Core Sample Response to Trash.

To well-mixed samples of chipped and hand-cleaned cane were added known quantities of green leaves, dry leaves, and 3 types of soil, i.e., Commerce, Mhoon, and Sharkey. The subsequent samples were then processed in the hydraulic press to determine the effect of different types of trash on the predicted cane quality.

Variability Among Core Samples.

The variation in cane quality among core samples from the same load was investigated. Additionally, correlations were developed indicating any bias induced by the location of the core sample.

Correlation of Cane Quality by Cane Sampling With That From the Farrel Mill.

Correlations were developed relating the predicted yield by core sampling with that from simulated commercial-scale milling on the Farrel sample mill. In these studies, subsamples from the same core sample were used for the press and for the mill.

Correlation of Cane Quality by Core Sampling With That From the Factory Mill.

In a manner similar to the above, correlations were developed relating the predicted yield by core sampling with that from the factory Squier mill. In this case, the cane consignments were core sampled and then processed in the factory mill.

EQUIPMENT AND PROCEDURE

Equipment

The Core Sampler: The J & L Model X-2 Core Sampler is an electro-pneumatically operated device with an 8-in. diameter coring tube which enters the cane delivery from top to bottom with an inclination of 45° to the vertical plane. The core sample is automatically discharged into a Rietz Model PB10 prebreaker for sample attrition. This equipment was loaded at the Cinclore Factory.

The Hydraulic Press: The Pinette-Emidecau Type OB102 Hydraulic Press has a 5-11/16-in. diameter x 6-1/8-in. long perforated cylinder and a piston capable of exerting a maximum pressure of 3600 psig. The capacity of the press is about 2 lb of prepared sample.

The Farrel (Sample) Mill: This 3-roll (12-in. dia. x 12-in. long rolls) mill is powered with a 15 HP variable speed motor drive assembly and includes a hydraulic system capable of delivering up to 40 tons per foot of roll length.

The Audubon Sugar Factory Mill: The Squier milling tandem is made up of a 20 in. by 24 in. Fulton-type 2-roll crusher, followed by 3 triangular stress 18-1/2 in. by 24 in. 3-roll mills. The individual milling units are each driven by a direct current motor through double reduction Falk gearing. Roll pressures are maintained by Edwards Accumulators at the ends of the top roll of each mill.

The Cane Chipper: The cane chipper consists of a steel hub which is machined to receive 4 knife blades. An anvil bar is located with close tolerance to the revolving knife blades. A high degree of cane disintegration is achieved by passing about 3 stalks of hand-cleaned cane at the ends of the top roll of each mill.

Procedure

Core Sample Procurement: Both bulk cane and single bundles were sampled. The sampling entailed removing one or more samples from field carts. When possible, 3 samples were removed, one each from the back, middle, and front of the conveyance (with the front being the end toward the tractor).

The Press Processing Procedure: After passing through the pre-breaker on the coring machine, the entire core sample (about 30 lb) was collected in a plastic bag and transferred to LSU for immediate analysis. In the case of anticipated delays, the core samples were stored in the factory freezer. Prior to pressing, the core samples were placed in a Y-blender for 5 min to ensure homogeneity of the samples. A 1000 g subsample was then removed from the blended sample for each determination required. The weighed (1000 g) charge to the press was loaded into the press cylinder and put under constant pressure for 5 min. The juice was collected in a tared container and weighed, and the bagasse was removed and weighed. The juice brix was determined using a Schmidt and Haensch refractometer at constant temperature. The juice pol and the bagasse pol and moisture were determined by the conventional methods described below.

The Cold Water Digestion Processing Procedure: For the direct determination of pol in cane using a 1-gal Waring blender, the standard method for bagasse analysis was employed except that 200 g of cane were used together with 1000 g water (to which 0.25 g of Na_2CO_3 had been added). The cooled juice extract after 10 minutes of blending was then analyzed for pol, and the pol % cane was calculated.

The Farrel Mill Processing Procedure: Commercial-scale extraction-severity was simulated by passing the cane and subsequent bagasse 4 times through the mill. However, no maceration water was added. Cane, juice, and bagasse weights were determined - and juice and bagasse samples analyzed.

Studies on Sample Reproducibility, Processing Techniques, and the Effect of Trash: In the studies on press reproducibility and cane quality by different sample processing techniques, the core samples were well blended and subsampled for the subsequent processing. For the effect of trash, hand-cut, topped, and cleaned cane was prepared in the chipper after which it was blended and then subsampled. Varying quantities of different types of trash were then added to the individual subsamples.

Variability Among Core Samples by Location.

Samples were removed from 2 or more locations in the field carts (both bulk and slinged bundles). The individual samples were well mixed and the subsamples processed in the press.

Correlation of Cane Quality by Core Sampling With That From the Farrel Mill: The press- and Farrel-mill data from 11 of the processing technique runs were reduced to recoverable sugar as discussed below and correlations developed which related the predicted recoverable sugar.

Correlation of Cane Quality by Core Sampling With That From the Factory: For each run, a 2 to 3 ton slinged bundle of cane was transported from the field to the core sampler by means of a field cart. After coring, the bundle was transferred to a truck and delivered to the Audubon Sugar Factory along with the core sample. At the factory, the cane was weighed, transferred to the feeder table, and a trash sample removed. The core sample was blended and a subsample processed in the press. The cane consignment was processed in the factory mill with 20% maceration water and a last mill-roll speed of about 30 feet per minute. During milling, samples of crusher and last roll juice and bagasse were removed and composited. Following the run, bagasse and juice weights and maceration water volume were determined. Samples of mixed juice were removed from the weighing tank, and the crusher, mixed, and the last roll juice and the bagasse samples were transferred to the laboratory for analyses. The core-press and the factory recoverable sugar were then correlated.

Trash Determination: About 100 lb of cane were removed from the feeder table by mechanical grab and weighed. The sample was then hand-cleaned after which the clean cane weight was determined and the trash calculated by difference and expressed as trash % cane.

Analyses: Juice analyses included brix by a Schmidt & Haensch refractometer and pol by the Horne's dry lead method. Bagasse was analyzed for moisture with the Dietert Model 278A Moisture Teller. Pol in bagasse was determined by the wet disintegrator method in which 100 g of bagasse was mixed with 1000 g of water (to which 0.25 g of Na_2CO_3 had been added) and blended in a 1-gal Waring blender. The juice extract after 10 min of blending was then analyzed for pol by the conventional method. Brix in bagasse was calculated from the pol and the mill

juice purity (last roll juice for the factory mill and extracted juice purity for the Farrel mill). Fiber was by the indirect method, i.e., 100.00 - (moisture + brix).

Data Reduction: In the studies on the variability among core samples from the same load and the correlations with the Farrel and the factory mill, the final data were expressed in terms of recoverable sugar. Three recoverable concepts were used. These included:

TRS = theoretical recoverable sugar, lb 96° sugar/gross ton cane.

CRS = corrected recoverable sugar, lb 96° sugar/gross ton cane.

RS = recoverable sugar, lb 96° sugar/gross ton cane.

TRS was the predicted recoverable sugar in the core samples assuming specific extraction and boiling house performance. RS was the predicted mill-recoverable sugar, also assuming specific extraction and boiling house performance.

By means of a liquidation factor F, which related the sum of the sample theoretical recoverable sugar to the mill recoverable sugar, the corrected recoverable sugar for each press run was then calculated. The liquidation factor was calculated as:

$$F = \frac{\sum RS}{\sum TRS}$$

The corrected recoverable sugar was then:

$$CRS = TRS \times F$$

Both the sample and the mill recoverable sugar calculations assumed the Winter-Carp retention formula and a 96.00 boiling house efficiency. The extraction for the Farrel mill assumed a milling loss (pol/bagasse x 100) of 7.00%, while the actual extraction was used for the factory mill.

Two methods for handling the extraction for the sample TRS were used, i.e., method 1 and method 2. Method 1 assumed a reduced extraction of 91.90 from which the corresponding absolute juice % bagasse of 56.67 was calculated. Method 2 was simplified approach and assumed that the extraction was solely a function of the fiber content of the cane as reflected by the absolute juice % cane. This overstated the yield in assuming 100% extraction. The calculation methods for determining the sample theoretical sugar and the Farrel mill recoverable sugar are shown in the Appendix.

RESULTS

Hydraulic Press Reproducibility.

This series of experiments consisted of 9 core samples, each of which was thoroughly blended and subdivided into 3, 4, or 5 subsamples. Each of the subsamples was then processed on the hydraulic press to determine the basic juice and bagasse quantity and quality, the pol extraction, and the direct cane data as pol, brix, and fiber % cane. These results are tabulated in Table 1 for one core sample together with the average values and coefficient of variation for the 9 runs in this test series.

The coefficient of variation for the various parameters was generally less than 0.5% for the juice analyses (brix, pol, and purity), and about 2% for bagasse related data (bagasse % cane, moisture and pol % bagasse, and fiber % cane).

These results indicate that the press method and analytical techniques used are highly reproducible. However, they point up the fact that it is the fiber component of the cane that is the most variable of the quality parameters.

Table 1. Press reproducibility - Typical run and replicate run averages.

	Run No. 25B - Subsample No.							Average for 9 runs	
	1	2	3	4	Avg	Std. Dev.	% C.V.	Avg	% C.V.
Juice wt, g	610	586	592	569	589.25	16.92	2.87	553.34	2.18
Bag wt, g	393	398	430	430	407.50	16.42	4.03	442.57	2.15
Cane wt, g	1000	1000	1000	1000	1000			1000	
Loss, g	-3	16	-1	1	3.25			4.09	
Juice: Brix	14.87	14.87	14.87	14.97	14.90	0.05	0.34	15.83	0.35
Pol	10.02	10.04	9.99	9.99	10.01	0.02	0.24	11.54	0.45
Purity	67.38	67.52	67.18	66.73	67.20	0.34	0.51	72.68	0.53
Bagasse, % moist.	46.4	48.3	47.7	50.2	48.15	1.58	3.28	43.95	2.44
% pol	5.24	5.24	5.10	5.24	5.21	0.07	1.34	5.54	1.76
% fiber	45.82	43.94	44.71	41.95	44.11	1.63	3.70	43.58	2.23
Bag % cane	39.30	39.80	40.90	43.00	40.75	1.64	4.03	44.26	2.18
Cane, % pol	8.14	8.13	7.99	7.95	8.05	0.10	1.20	8.91	0.91
% brix	12.08	12.04	11.89	11.91	11.98	0.09	0.79	12.20	0.81
% fiber	18.01	17.49	18.29	18.04	17.97	0.34	1.87	21.24	2.17
Pol extraction	74.71	74.35	73.89	71.65	73.65	1.37	1.87	71.99	1.52

Comparison of Cane Quality by Different Sampling Processing Techniques.

These investigations compared cane quality as determined from the press, the Farrel mill, and cold digestion. Ten core samples were blended and 3 subsamples removed. These subsamples were processed by the above sample processing schemes. Table 2 shows the direct data as pol, brix, and fiber % cane for 5 runs, the average for the entire 10 runs, and the correlation between the press and Farrel mill data.

Table 2. Cane quality by press, Farrel mill, and cold water.

Run no.	Item	% cane			r ²
		Press	Farrel	Digestion	
8	Pol	12.55	12.73	12.30	
	Brix	14.85	14.99	-	
	Fiber	17.01	13.40	-	
9	Pol	13.77	13.92	13.68	
	Brix	15.84	15.97	-	
	Fiber	16.72	13.86	-	
19	Pol	10.32	10.35	10.30	
	Brix	13.05	13.05	-	
	Fiber	13.25	11.10	-	
20	Pol	12.04	12.22	11.72	
	Brix	14.68	14.83	-	
	Fiber	15.65	12.73	-	
21	Pol	11.87	11.92	11.76	
	Brix	14.28	14.29	-	
	Fiber	14.17	13.91	-	
Average	Pol	12.11	12.23	11.95	
	Brix	14.54	14.63	-	
	Fiber	15.36	13.00	-	
10 run avg.	Pol	11.24	11.49		0.9820
	Brix	13.91	14.15		0.9301
	Fiber	15.60	13.65		0.6615

The cold water digestion or wet disintegrator method is recognized to be the most accurate (but time consuming) method for determining pol in cane and in bagasse samples. In this test series, the pol % cane by this method was considered to be the true value.

Pol in cane by the press method averaged 1.3% higher than by cold digestion, while the corresponding value for the Farrel mill was 2.3% higher. This phenomenon is attributed to the presence of field soil in the cane - and subsequently the extracted juice. The soil does not affect the juice quality but it does increase the apparent quantity, thus giving a higher apparent pol % juice and subsequent pol % cane. A corollary effect is that the field soil in the juice does not appear in the bagasse thereby contributing to a lower fiber % cane, (the natural fiber plus insoluble solids in the juice).

The greater pol % cane by the Farrel mill than by the press is due to the fact that more field soil enters the juice in the milling process than in the pressing operation - where the juice is screened through a thicker layer of bagasse. This would also account for the higher brix % cane and lower fiber as compared to the press and the poor fiber correlation.

It is evident from this series of studies that the press is a better sensor of fiber than the small mill. As for the cold digestion method, it is recognized that this scheme does not lend itself to determining fiber in the presence of any appreciable quantity of field soil.

Core Sample Response to Trash.

In this test series, cane was hand cut, cleaned, topped, prepared in the chipper, and blended. Trash was added in varying proportions to the subsamples - and the subsample blended and processed in the press.

Three types of trash were compared to include green leaves, dry leaves, and field soil. The field soil included samples of Commerce soil (which is high in sand content), Sharkey (which is primarily clay and high in organic matter), and Mhoon soil (which is intermediate between Commerce and Sharkey soil in texture). The moisture content of the trash is shown below:

<u>Trash</u>	<u>% moisture</u>
Green leaves	60.1
Dry leaves	1.1
Commerce soil	19.9
Mhoon soil	18.5
Sharkey soil	20.4

The effect of increasing quantities of trash on bagasse, fiber % cane, and on juice purity is shown in Table 3.

In all cases there was an increase in bagasse and fiber % cane with increasing trash. With respect to fiber, the order of magnitude of the effect of trash from greatest to least was Commerce soil and dry leaves, Mhoon soil, Sharkey soil, and green leaves (least). At the low end of the spectrum, 5% green leaves on cane contributed to an increase of about 1% fiber. However, the effect of trash on bagasse is a little more difficult to interpret. Both Commerce and Mhoon soil contributed to a marked decrease in bagasse moisture as well as pol. Sharkey contributed to a slight increase in bagasse pol and moisture. Increasing quantities of green and dry leaves resulted in little change in bagasse quality.

Relative to the effect on purity, as expected green leaves gave a perceptable purity drop on the order of 2.4 purity points per 5% trash. The effect of dry leaves was a purity depreciation of about 1.4 purity points per 5% trash. Sharkey and Commerce soil exhibited a negligible effect. Contrary to expectations, and for reasons unknown, Mhoon soil gave a purity increase of the order 1.4 points per 5% trash.

Table 3. Core sample response to trash as leaves and field soil.

Type of trash	Bagasse % cane for following trash percentages				
	0	4.76	9.09	16.67	r ²
Green leaves	28.8	30.2	32.7	35.7	0.9900
Dry leaves	27.0	32.5	40.2	51.9	0.9953
Mhoon soil	28.7	30.6	32.1	35.8	0.9945
	0	5.37	10.44	15.27	
Sharkey soil	26.9	29.9	42.0	46.3	0.9409
	0	6.43	12.46	19.99	
Commerce soil	24.1	26.1	29.5	35.7	0.9590
	Fiber % cane for following trash percentages				
	0	4.76	9.09	16.67	r ²
Green leaves	12.28	12.92	13.64	15.71	0.9707
Dry leaves	12.43	15.44	19.25	23.46	0.9921
Mhoon soil	11.94	15.59	18.21	21.48	0.9797
	0	5.37	10.44	15.27	
Sharkey soil	13.66	16.79	19.92	21.34	0.9811
	0	6.43	12.46	19.99	
Commerce soil	12.49	16.20	19.69	25.23	0.9811
	Juice purity for following trash percentages				
	0	4.76	9.09	16.67	r ²
Green leaves	83.65	82.13	79.69	75.78	0.9903
Dry leaves	79.37	77.55	75.91	74.80	0.9452
Mhoon soil	78.87	79.08	79.63	83.58	0.8379
	0	5.37	10.44	15.27	
Sharkey soil	81.97	82.13	82.61	81.90	0.0161
	0	6.43	12.46	19.99	
Commerce soil	84.93	83.88	84.62	83.94	0.3283

Variability Among Core Samples by Sample Location.

Eighteen deliveries were sampled at 2 or more locations in the conveyance. In 8 of the runs, 3 samples were removed from the back, middle, and front. In addition to the usual direct cane quality data of brix, pol, and fiber % cane, the theoretical recoverable sugar (TRS) as 1b 96° sugar per ton of cane was calculated by Method 1. Table 4 shows the data for a 3-sample run, the coefficient of variation for all 18 runs, and the average TRS for the 8 runs in which 3 samples were removed.

The results obtained were similar to the reproducibility studies on the press, but the variations were greater - as would be expected due to the inclusion of the additional variable of sample location. The juice and bagasse inspections showed coefficients of variation of about 3 and 5% respectively.

While the cane quality varied by sample location, as shown by the data for Run no. 4, there was no bias associated with the sample location, as indicated by the recoverable sugar data for the 8 run average (which included the usual front, middle, and back samples). A similar conclusion was reached with the 1972 studies.

Table 4. Variability among core samples from the same load.

	Run no. 4				Std. dev.	% C.V.	Average
	Back	Mid	Front	Avg.			% CV (18 runs)
Juice wt, g	641	635	613.5	629.8	14.46	2.30	7.48
Bagasse wt, g	354	362	381.5	365.8	14.15	3.87	9.01
Cane wt, g	1000	1000	1000	1000			
Juice, % brix	19.02	18.52	18.32	18.62	0.36	1.94	2.75
% pol	13.32	12.40	12.49	12.74	0.51	3.98	4.46
purity	70.04	66.94	68.18	68.39	1.56	2.27	2.16
Bagasse, % moist.	46.6	45.9	45.70	46.07	0.47	1.03	4.54
% pol	8.26	7.51	6.68	7.48	0.79	10.56	5.88
% brix	11.80	11.21	9.80	10.94	1.03	9.40	5.20
% fiber	41.61	42.89	44.51	43.00	1.45	3.38	5.36
Cane, % pol	11.53	10.63	10.28	10.81	0.64	5.96	5.06
% brix	16.47	15.88	15.07	15.81	0.70	4.45	3.40
% fiber	14.73	15.53	16.98	15.75	1.14	7.24	7.97
Bagasse % cane	35.4	36.2	38.15	36.58	1.41	3.87	9.01
Pol extraction, %	74.64	74.44	75.20	74.76	0.39	0.53	5.19
TRS	176.2	155.1	149.7	160.4	14.01	8.74	7.36
TRS (18 run avg.)	184.2	179.8	182.8	182.3			

Correlation of Cane Quality by Core Sampling With That From the Farrel Mill.

This was the first of the investigations in which the sample cane quality as sugar yield was compared with that from the mill. The core-press and Farrel mill data from 11 of the processing technique runs were reduced to the predicted recoverable sugar yield, lb 96° sugar/gross ton cane.

As noted in the procedure for data reduction, for both the press and the mill, the recoverable sugar formula assumed the Winter-Carp theoretical retention and 96.00 boiling house efficiency. The mill extraction efficiency assumed a milling loss (pol/fiber in bagasse) of 7.00% and the predicted mill yield was the recoverable sugar (RS). Two methods of predicting the sample extraction were used. Method 1 assumed a 91.90% extraction with a corresponding 56.67% absolute juice in bagasse % cane. Method 2 assumed 100% extraction, i.e., complete recovery of the absolute juice in the cane. The sample yield was expressed as theoretical recoverable sugar (TRS). The degree of correlation was determined between the mill yield and that of the sample as calculated by Methods 1 and 2.

Finally, the total theoretical recoverable sugar (TRS) from the core-press was factored to the total mill recoverable sugar (RS) to obtain the liquidation factor F. This factor was then applied to each of the core-press yields to obtain the corrected recoverable sugar (CRS).

Table 5 shows the data from the 11 runs.

Although both Method 1 and Method 2 shows extremely good correlation with the Farrel mill, that by Method 1 was slightly better and this method was used in subsequent correlations.

Table 5. Correlation of theoretical recoverable sugar (TRS) from the core sample with the Farrel mill predicted yield (RS) and the corrected recoverable sugar (CRS).

Run no.	lb 96° sugar/gross ton cane				
	TRS		CRS		RS
	Method 1	Method 2	Method 1	Method 2	Farrel
8	205.6	228.6	216.5	213.6	219.1
9	229.4	257.3	241.6	240.4	243.7
10	247.2	291.1	260.3	272.0	258.4
14	162.3	182.7	170.9	170.7	168.6
15	143.0	167.1	150.6	156.2	145.9
16	137.6	148.5	144.9	138.8	145.2
17	173.9	200.4	183.1	187.3	191.2
18	200.2	230.0	210.8	214.9	219.2
19	168.6	183.9	177.6	171.9	171.5
20	196.6	219.5	207.0	205.1	207.2
21	197.7	214.9	208.2	200.8	201.6
Average	187.5	211.3	197.4	197.4	197.4
r^2	0.9819	0.9718			
r	0.9909	0.9858			

Correlation of Cane Quality by Core Sampling With That From the Factory Mill.

Similar recoverable sugar correlations were derived between the core sample and the sampled consignment after milling in the Audubon Sugar Factory tandem. Milling conditions included 20% maceration on cane. Method 1 was used for the predicted sample yield, and the actual mill extraction was used for the predicted mill yield. Results of the studies for 9 runs are presented in Table 6.

Table 6. Comparison of theoretical recoverable (TRS) from the core sample with the factory predicted yield (RS) - and the corrected recoverable sugar (CRS).

Run no.	lb 96° sugar/gross ton cane		
	TRS	CRS	RS
	Method 1	Method 1	Factory
1	163.4	169.4	164.9
2	171.3	177.5	171.4
3	135.6	140.5	163.9
4	157.5	163.3	164.6
5	168.7	174.9	193.4
6	194.7	201.9	192.7
7	169.4	175.6	178.0
8	205.6	213.1	205.1
9	229.4	237.8	220.2
Average	177.3	183.8	183.8
r^2	0.8433		
r	0.9183		

The core-press and factory-mill data by run are shown in the Appendix Tables A-1 and A-2. Very muddy field conditions contributed to a large volume of trash (particularly field soil) in the cane. This posed problems in getting representative samples of a consignment and a good material balance around the mill. As a result, rather poor agreement between sample and mill data are noted for individual runs, such as Nos. 3 and 5. Nevertheless, the overall correlation

between the core-press theoretical sugar (TRS) and the mill predicted recoverable sugar (RS) was considered to be highly significant with a correlation coefficient of 0.9183.

Correlation Between the Core-Press and the Conventional Sampling System.

The factory mill cane consignments for the core-press mill comparison above were sampled for trash and crusher juice quality. From these data the standard/gross tons were calculated. The core-press TRS and the conventional standard/gross tons were then correlated with the mill RS. As with the 1972 studies, the conventional system was idealized in that the trash determinations were closely supervised and the crusher juice quality was used rather than the sample mill juice and average sample mill-normal juice factors. The results of these studies are summarized below:

<u>Sample Scheme</u>	<u>r</u>
Idealized conventional system	0.8104
Core-press	0.9183

From the above, and from the tests with trash mingled with clean cane, it is evident that the press very effectively sensed trash.

CONCLUSIONS

1. The hydraulic press method of cane analyses is very reproducible.
2. The pol % cane by the hydraulic press compares favorable with that by the cold water digestion method.
3. The hydraulic press is very responsive to trash. The increase in apparent fiber is directly proportional to the quantity of trash in the cane.
4. Multiple corings of the cane consignments indicate a variability of cane quality within the consignment. However, there is no bias associated with the location of the sampling point.
5. The quality of the cane consignment as determined by the core-press correlates well with that as determined from subsequent processing of the consignment in the factory mill.

RECOMMENDATIONS

1. These studies should be expanded to a factory-scale, sampling at the same frequency as the conventional method. The purpose of these tests is to determine such mechanical aspects as corer service factor, volume of samples which can be handled, personnel and equipment requirements, and station orientation and layout.
2. To simplify sample analyses, a modification of the time-consuming bagasse inspections should be investigated. This may take the form of bagasse moisture only and calculation of the bagasse brix, pol, and fiber from the juice inspections and the bagasse moisture.
3. Consideration should be given to problems incurred where more than 3 hours elapse between sampling and processing. In such cases, methods of sample preservation will have to be devised.
4. The press method should lend itself to varietal evaluation studies in lieu of the VCF method used in Louisiana and Florida - or the cold water digestion method in other areas of the world. In this regard, the juice purity may be slightly higher by the press method since the residual juice in bagasse is assumed to be the same as that of the extracted juice.

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APPENDIX

Sugar Yield Calculation Methods.

Yield is expressed as lb 96° sugar/gross ton cane.

Method No. 1

$$\text{Yield} = 2000 \times \frac{\text{pol \% cane}}{100} \times \frac{\text{extraction}}{100} \times \frac{\text{retention}}{100} \times \frac{1}{0.96}$$

$$\text{where: extraction} = \left[100 - \frac{(\text{abs. juice in bag. \% fiber}) \times (\text{fiber \% cane})}{100 - \text{fiber \% cane}} \right]$$

$$\text{retention} = \left[1.4 - \frac{40}{P} \right] \times 96.00$$

where: P is the absolute juice purity

96.00 is the boiling house efficiency

Assuming a reduced extraction of 91.90, the yield reduces to:

$$\text{Yield} = (0.2800S - 0.0800B) \left[100 - \frac{56.67F}{100-F} \right]$$

where: F is the fiber % cane

S is the sucrose % cane

B is the brix % cane

Method No. 2

$$\text{Yield} = 2000 \times \frac{\text{abs. juice \% cane}}{100} \times \frac{\text{pol \% extracted juice}^*}{100} \times \frac{\text{retention}}{100} \times \frac{1}{0.96}$$

where: absolute juice % cane = 100 - fiber % cane

retention as by Method no. 1

pol extraction is assumed to be 100% (no fiber effect on extraction)

This reduces to:

$$\text{Yield} = (28.00S - 8.00B) \times \left[\frac{100 - \text{fiber \% cane}}{100} \right]$$

where: S is the sample juice pol % cane,

B is the sample juice brix % cane

*Assumes absolute juice and extracted juice quality are the same for the sample (no maceration water).

Farrel Mill

$$\text{Yield} = 2000 \times \frac{\text{fiber \% cane}}{100} \times \left[\frac{\text{pol \% cane}}{\text{fiber \% cane}} - \frac{\text{milling loss}}{100} \right] \times \frac{\text{retention}}{100} \times \frac{1}{0.96}$$

where: Milling loss (pol % fiber in bagasse) is assumed to be 7.00,

retention as by Methods 1 and 2.

Factory Mill

$$\text{Yield} = 2000 \times \frac{\text{pol \% cane}}{100} \times \frac{\text{extraction}}{100} \times \frac{\text{retention}}{100} \times \frac{1}{0.96}$$

where: extraction is the actual factory extraction,

retention is determined as above but using the mixed juice purity.

Table A-1. Factory mill data.

		Run no. and date								
		1	2	3	4	5	6	7	8	9
		10/23	10/24	10/25	10/26	11/08	11/16	11/28	12/12	12/18
% cane:	trash	16.00	11.00	16.00	15.00	26.00	16.00	10.00	12.00	5.00
	maceration	20.79	19.95	21.39	20.90	19.72	24.38	24.02	19.01	19.26
	mixed juice	88.87	87.24	86.64	87.21	86.77	91.29	87.18	88.45	88.06
	bagasse	31.92	32.71	34.75	33.69	32.94	33.09	36.84	30.56	31.20
	pol	10.55	11.69	11.44	11.37	11.89	12.13	11.64	12.58	13.51
	brix	14.31	16.22	16.10	15.74	14.70	14.99	14.49	15.21	16.31
	fiber	14.16	13.37	14.31	14.23	15.06	13.34	15.54	13.19	13.30
Crusher juice:	brix	17.54	18.55	18.72	18.69	18.18	17.78	18.58	17.48	18.99
	pol	13.69	14.46	14.25	14.33	15.72	14.89	15.81	14.82	16.45
	purity	78.05	77.95	76.12	76.67	86.47	83.75	85.09	84.78	86.62
Mixed juice:	brix	14.44	15.73	15.41	15.33	14.98	14.18	13.88	14.98	16.26
	pol	10.75	11.51	11.16	11.12	12.24	11.59	11.26	12.56	13.58
	purity	74.45	73.17	72.42	72.54	81.71	81.73	81.12	83.85	83.52
Last roll juice:	brix	8.43	8.43	8.80	7.92	7.14	8.57	8.97	7.24	8.14
	pol	5.66	5.55	5.68	5.60	5.33	6.51	6.68	5.43	6.34
	purity	67.14	65.84	64.55	70.71	74.65	75.96	76.48	75.00	77.89
Bagasse:	brix	4.63	7.64	7.90	7.02	5.17	6.17	6.49	6.43	6.37
	pol	3.11	5.03	5.10	4.96	3.86	4.69	4.96	4.82	4.96
	moisture	51.00	51.50	50.93	50.70	49.10	53.50	51.33	50.40	51.00
	fiber	44.37	40.86	41.17	42.28	45.73	40.33	42.18	43.17	42.63
Pol extraction		90.59	85.92	84.51	85.30	89.31	87.21	84.31	88.30	88.54
1b 96° sugar/gross ton (RS)		164.9	171.4	163.9	164.6	193.4	192.7	178.0	205.1	220.2

Table A-2. Core-press data.

		Run no. and date								
		1	2	3	4	5	6	7	8	9
		10/23	10/24	10/25	10/26	11/08	11/16	11/28	12/12	12/18
% cane:	trash	16.00	11.00	16.00	15.00	26.00	16.00	10.00	12.00	5.00
	mixed juice	66.20	63.38	55.17	63.42	56.93	67.80	59.67	63.50	64.50
	bagasse	33.80	36.62	44.83	36.58	43.07	32.20	40.33	36.50	35.50
	pol	10.63	11.35	9.63	10.81	10.74	11.76	11.06	12.55	13.77
	brix	14.43	15.80	14.41	15.81	13.32	14.40	14.73	14.85	15.84
	fiber	15.43	15.67	17.68	15.75	21.22	13.77	17.13	17.01	16.72
Press juice:	brix	16.90	19.05	17.65	18.62	17.05	16.71	18.18	17.58	18.89
	pol	12.45	13.67	11.79	12.74	13.73	13.65	13.65	14.86	16.43
	purity	73.66	71.77	66.78	68.40	80.53	81.67	75.27	84.53	86.98
Bagasse:	brix	9.57	10.17	10.44	10.94	8.09	9.45	9.55	10.10	10.29
	pol	7.05	7.30	6.98	7.48	6.66	7.71	7.12	8.54	8.95
	moisture	44.77	46.92	49.37	46.07	42.27	47.63	47.60	43.30	42.60
	fiber	45.66	42.91	40.19	42.99	49.64	42.92	42.85	46.60	47.11
Pol extraction		77.55	76.36	67.11	74.76	72.69	78.73	73.65	75.17	76.93
1b 96° sugar/gross ton (TRS)		163.4	171.3	135.6	157.5	168.7	194.7	169.4	205.6	229.4

CHANGES IN ROW SPACINGS IN LOUISIANA ^{1/}

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ABSTRACT

The traditional row spacing for sugarcane in Louisiana is 6 ft, with a single drill per row. Seven years of research on row spacings have shown that yields can be increased by a reduction in row width or by double-drill planting. Rows 3- to 3 1/2-ft wide yielded 49% more than standard width. Rows 4-ft wide increased yields 35%. However, narrow rows are difficult to manage and are easily damaged by equipment. Double drills on 6-ft or 7-ft rows are more difficult to manage than single drills on 6-ft rows, but easier than on narrow rows. Two drills 15 in. apart on 6-ft rows increased yields 23% over standard rows in plant cane, but failed to increase yields in first stubble because of close spacing between drills. On 7-ft rows, 2 drills 30 in. apart increased yields 28% above that of standard rows. The 30-in. spacing between drills might maintain this advantage in the stubble crops.

^{1/} Research at this location is done in cooperation with the Louisiana Agricultural Experiment Station.

CHANGES IN ROW SPACING IN LOUISIANA

Harold Willett
Cameco
Thibodaux, Louisiana

Mr. Chairman and fellow member technologists. Thank you for asking me to take part in this panel, which discusses a topic that is important to the future of the Louisiana sugar industry.

My first encounter with double-drill spacing was a few years ago when I visited a sugar company on the island of Kauai in 1971. I had visited Olokele to discuss building a carrier for a replant machine that would work on hillsides. In our discussions in the office, before going to the field, I had mentioned that because of their 5 1/2-foot rows any machine that we built would be a monster with a 11-foot track. The manager said, "Let's go to the field, we have made a change that gives us more cane, facilitates our trickle irrigation, and I believe is a machinery man's dream". We went to the field, and for the first time I saw a change that to me is a machinery man's dream come true.

On my return home from Hawaii I had a lot of time in the airplane, and after a couple of drinks I started thinking of the many possibilities this change in plant spacing held for us. It excited me from the mechanical point of view, and, as soon as I could, I talked to farmers to put in a block that could give us some field experience. One plot on the farm of Warren Harang, Jr. was planted in 1972 by our Sales Department, and the second plot was planted at Goldmine Plantation by Mr. Stan Rodrigue. I won't cover the field results because other members of the panel will talk on this. I do want to cover the mechanical advantages that are available with this system. I also would like to make a plea that, if we go to this change, we standardize on one set measurement.

First of all I would like to cover my first point of how this helps the mechanical operation.

1) Horsepower is increasing each year to get more productivity from man and machine. This increase in horsepower means wider engines, bigger tires and the need for mud clearance. To illustrate this let's look at Slide #1 which gives a comparison of a 50 HP engine formerly used on the UC.D and a 150 HP engine that is getting common in the Louisiana cane belt. There is a difference of 12" in width between these 2 engines. To transmit this horsepower to the ground we need wide tires. Let's look at a 100 HP tractor in our present row spacing. This tractor with the proper tires does not fit in the Louisiana row today. Note that it lacks about 4" before centering in the row. What happens when we need larger tractors to change from 3-row equipment to 5-row equipment or its equivalent in double-drill planting? To progress mechanically we need room to breathe; please give it to us with wide spacing.

2) We need stability for our mechanical equipment. Today in Louisiana all our equipment is getting more unstable as we get bigger, because as we get bigger we have to go "up" not "out" as has been done in other crops. This means the center of gravity moves upwards and we have more and more accidents. I believe we have reached our limits and some of our government agencies are going to begin to get after us on this. Let's review some slides on our present equipment to illustrate this point. Remember, our row spacing was established many years ago because a mule would fit a 5-foot to a 5 1/2-foot row. Let's not stay in the mule stage.

3) The double-drill planting opens new horizons for harvesting because for once it gives us room to breathe. This is true whether it is in our present cut-then load system or in combine harvesting. I would like to illustrate some of these points:

a) To get a good stubble job and eliminate scrap, I feel we must go to a double bottom-blade so cane is swept into the center of the harvester. This has been proven in Australia, and we had one machine operating in Louisiana for 2 years with double blades. Our machine showed less scrap, but again the blades could not be set side-by-side because of our row spacing. I feel with double-drill spacing we can run 2 blades comfortably side-by-side and improve our cutting considerably and reduce scrap.

b) More and more cleaning will have to be done in harvesters of the future. To clean the cane in the field we will need more horsepower. By widening the row we can have more room to put in this horsepower and have room to install some cleaning devices. On today's machines there is no room to do this.

c) If we ever go to combines, the double-drill spacing is, I feel, a make-or-break factor in this change. I believe under our present conditions we would never have the soil-bearing

capacity to support a machine with a boom hanging over the side. This is especially true when the wagon has to be in the next row. With double-drill planting, the wagon is moved over, the machine has a broader base, and there is more room for the cleaning equipment. Our combine we are working on will be equipped to cut double-drill planting, and the men working on it constantly say, "How much easier it would be if we only had to work on double-drill spacing."

d) In double-drill planting the linear feet of travel per acre is reduced considerably. This means faster operations, less field damage, and a more efficient operation.

I could go on for hours on the many advantages in double-drill spacing. I believe it has as many advantages in planting, cultivation, etc., but I do want to leave time for my other panel members and for general discussion.

I do want to take a minute of time to caution all of us of one thing: Please, if we convert, let's not do like we did with changing to chain net. Everyone went their own way; we have transport units with manifolds on both sides; we have many, many types of manifolds, and all different lengths of chain. This is giving us fits as mills are being consolidated. I feel a committee should be formed with farmers, scientists, machinery people and economic advisors to guide this program to a successful end.

DOUBLE-DRILL PLANTING OF SUGARCANE IN LOUISIANA

Stan Rodrigue
Gold Mine Plantation
Edgard, Louisiana

In November of 1972 we planted about 1 acre of double-drill sugarcane on 7 1/2' rows, with the drills about 30" apart.

For this experiment, the field was marked one row at a time. The rows were left flat. Two small middle busters set 30" apart were used to open the furrows to receive the seed cane.

A planter's aid was used with 5 droppers, planting 3 double-drill rows at the time. The planting was 2 stalks with a 10% overlap per drill.

The cane was covered with 2 small single discs, passing the disc only on the outside of the 2 drills; then the middles were deepened with two middle busters.

The cane was fertilized and cultivated with our conventional equipment that had been modified.

Herbicides were applied, broadcast, in February and after lay-by in May.

The crop was cut with our standard Louisiana harvester, using a larger diameter bottom blade. We passed the 2 drills of growing cane through the harvester at one time. We made 2-row heaps, which contained 4 drills of cane. Fields were relatively dry at the time of harvest.

The cane was loaded with our standard Louisiana loader, using the extended boom to reach the wagons.

The yield obtained from these plots with the variety CP 48-103 on the double drill was 36.14 standard tons compared to 30.47 standard tons on the 6-ft rows, or an increase of 5.67 tons for the double-drill over the single-drill on 6-ft rows. This represents an increase of about 14%.

The problems that we find associated with the preceding steps will now be pointed out.

In November of 1973, we planted 1 acre of double-drill cane 30" apart, same spacing as in 1972, on 7' rows. We changed the row spacing from 7 1/2' to 7' because a) after observing the 1972 crop grow, we realized that there was still too much sunlight wasted between the rows, a conclusion reached by comparing the growing tendency of the plants between the drills and the rows; b) the middle of 7' double-drill cane seems to be large enough for equipment to travel.

Tractors and cultivating tools now in the cane belt are readily adaptable to 7' rows, single or 3-row equipment, by making simple adjustments.

A planter's aid was used but I am sure that a mechanical planter could be modified to do the same job.

In covering and cultivating the cane a depression formed between the 2 drills and I haven't been successful in preventing this. This depression can create a serious cutting problem with down cane.

Fertilizer rates will have to be determined for double-drill cane to obtain the full benefit of higher plant population.

There seems to be no problem with the application of herbicides between double-drill vs single-drill, except placing a wider band for the double-drill.

In cutting the double-drill cane on 7 1/2' or 7' rows, the harvester should be able to make 3-row heaps. The machine did a good job as long as it stayed on the hips of the rows.

The loader also had to be kept on the hips of the row to do a good job of loading. The extendable boom makes it easier to reach the wagons.

As a farmer having had only one year's experience with double-drill cane, I am not ready to sell this idea. There are many factors and questions yet to be resolved. The best way to get these answers is for more farmers to have a small double-drill plot.

WILL DOUBLE-DRILL PLANTING PAY?

R. Charles Hodson
Economist
American Sugar Cane League
New Orleans, Louisiana

Research indicates that double-drill planting can increase Louisiana sugarcane yields substantially. Assuming these data to be accurate, growers need to know 3 things: a) Is double-drill planting mechanically feasible to plant, cultivate and harvest? b) Is it practical?, and c) Will it pay?

We are here today to to discuss these points. I will attempt to show what the additional costs and returns might be for a farmer using double-drill planting over those for a farmer using conventional planting methods.

ASSUMPTIONS

Costs and returns on new farming practices can be very hard to determine. It is necessary to make various assumptions, since actual cost data on new practices usually do not exist.

I will make the following assumptions in my presentation:

- a) Two efficient farms, each harvesting 400 acres of cane per year. (133 acres of plant cane, 133 acres of first year stubble and 133 acres of second year stubble).
- b) Sugarcane is planted on conventional 6-foot rows on Farm A and on 7-foot double-drill rows on Farm B. The two drills would be approximately 30 inches apart.
- c) 25 tons per acre yield on Farm A. 30 tons per acre yield on Farm B. (This assumes a 20% increase in cane yield from double-drill planting).
- d) \$14.00 per ton total price for cane (includes molasses and conditional payments).
- e) One cane harvester required for each farm. A conventional harvester would cost approximately \$30,000 for Farm A. A harvester designed to cut double-drill cane on Farm B would cost approximately \$36,000.
- f) Loading and hauling cost of \$1.20 per ton.
- g) Landlord gets 1/5 and the grower gets 4/5 of the value of the cane delivered to the mill.
- h) Comparisons are based on estimates of the cost of inputs and the price of cane for the 1973 crop.

ADDED RETURNS

Research indicates double-drill planting may increase cane yields by as much as 28%. Growers do not necessarily achieve as high an increase in yields from new cultural practices as is shown in experimental plots. For this presentation I assumed an average yield increase of 20% for growers. Thus, if a grower had an average yield of 25 tons per acre with conventional planting practices, he might expect a yield of 30 tons per acre with double-drill planting.

The average total price for cane for the 1973 crop will probably be slightly over \$14.00 per ton. Assuming a price of \$14.00 per ton and a 5 ton increase in yield due to double-drill planting, returns per acre of cane would increase by \$70.00 (See Table 1).

Table 1. Returns per acre of cane on two sugarcane farms.

Item	Farm A ^{1/}	Farm B ^{2/}
Yield of cane (tons per acre)	25	30
Price of cane per ton	\$ 14.00	\$ 14.00
Total returns per acre of cane	\$350.00	\$420.00
Added returns from double drill	--	\$ 70.00

^{1/} Cane planted on conventional 6-foot rows.

^{2/} Cane planted on 7-foot double-drill rows.

ADDED COSTS

Harvester. One harvester costing \$30,000 would be used to harvest 400 acres of standard-planted cane on Farm A. One harvester costing \$36,000 would be used on Farm B to harvest 400 acres of double-drill cane. To harvest the double-drill cane, the harvester will probably operate at a slower speed than with the standard cane. This will be made up for, however, by there being fewer 7-foot rows than 6-foot rows in the same size fields. The harvester will also harvest more cane per acre in double-drill fields. A harvester for cutting double-drill cane would cost about \$3.00 more per acre than one that harvests standard cane.

Fertilizer. More fertilizer would be required due to added stalk population. A guideline that can be used is to increase the rates of fertilizer by the same percentage as the percentage increase in stalk population. Stalk population of double-drill cane is about 50 to 60% higher than for standard cane, so fertilizer rates should also be increased by 50 to 60%. Using this guideline, fertilizer costs would be \$9.00 per acre more for double-drill than for conventional planting.

Planting labor. Using the planters' aid, double-drill planting may require an additional man putting cane in the drill. At \$2.00 per hour and 133 acres of cane planted per year, this would add \$1.33 per acre to planting labor costs. Modifications would also have to be made in mechanical planters where they are being used.

Loading and hauling. Loading and hauling costs vary widely, but average about \$1.20 per ton. The added yield of 5 tons per acre for double-drill planting would add about \$6.00 per acre to loading and hauling costs. The added yield means more cane will have to be loaded and hauled.

Rent. In this example, the landlord gets 1/5 and the grower gets 4/5 of the value of the cane delivered to the mill. This would mean an added \$14.00 per acre in rent costs.

Table 2. Selected costs per acre of cane on two sugarcane farms ^{1/}

Item	Farm A ^{2/}	Farm B ^{3/}
Harvester ^{4/}	\$ 15.38	\$ 18.45
Fertilizer	15.00	24.00
Added planting labor		1.33
Change axle length on equipment ^{5/}		1.00
Loading and hauling costs	30.00	36.00
Rent	70.00	84.00
Total	130.38	164.78
Added costs from double drill		34.40

^{1/} Only those costs which will vary because of the different planting methods (conventional vs double-drill) are compared.

^{2/} Cane planted on conventional 6-foot rows.

^{3/} Cane planted on 7-foot double-drill rows.

^{4/} Costs include depreciation over 5 years and interest on investment (10% on average investment).

^{5/} Change axle length on equipment such as cane carts, nurse tank trailers, etc. Depreciation over 9 yr. and 10% interest on average investment.

TRANSITION PERIOD

The transition period from 6-foot rows to 7-foot double-drill rows will be difficult. Such a transition will take at least 3 years. During this period, growers will be switching equipment back and forth between the 6-foot and 7-foot rows.

Some small amount of 6-foot row equipment just may not work on 7-foot rows and will become either obsolete or of limited usefulness. It may be extremely hard for growers with small acreages of cane to make the change. They may own older and lighter tractors which do not have adjustable wheels, and they may not have the capital to make the substantial equipment changes that would be necessary.

The transition period will be troublesome for those making the change. The use of custom work or leasing of equipment may be helpful during this period.

This paper has not attempted to solve the problems involved during this transition period. Instead I have attempted to show how the costs and returns would compare for conventionally planted cane to those for double-drill planting.

CONCLUSIONS

Based on the assumptions in this paper, double-drill planting will pay. It has been shown that added profits of \$35.60 per acre can be gained from double-drill planting. Admittedly, many problems need to be ironed out. I have faith, however, in the researchers, equipment manufacturers, and sugarcane farmers of Louisiana. They have worked together countless times in the past to develop and modify equipment to plant, cultivate, and harvest sugarcane. Since we are looking at a new planting method which can increase our cane yields by 25 to 30%, I am sure we can get together and solve the problems involved. It can mean money in our pockets.

PROCESSING RESPONSE OF CUT-CHOP HARVESTED CANE - 1973 STUDIES

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ABSTRACT

As a general statement, mechanical harvesting in Louisiana has become synonymous with inferior cane quality resulting in decreased factory capacity and efficiency, and increased equipment, maintenance, and operating costs. The problem is particularly severe during the rainy harvest spells which are common to Louisiana, when a large volume of field soil accompanies the cane to the factory. A corollary to the preceding observation is the wide discrepancy between the available sugar in the cane as reported from the varietal outfield tests and the actual yields reported by the factories. It is recognized that for the growers, increased yields per acre are essential for a viable farming operation. By the same token, increased sugar yields per ton of cane and sustained factory throughput at the rated tandem capacity are equally essential to support the processing segment. Recognizing the problem, cooperative industry-research station studies were initiated in 1972 to investigate the current and alternative harvesting schemes. Among the specific areas of investigation was the performance of the cut-chop combine-type harvester. The Audubon Sugar Factory was responsible for the comparative factory processing response and quality of cane from the conventional and Louisiana prototype cut-chop harvesters. These studies were initiated during the 1972 crop. The 1973 studies covered 2 types of combine cut-chop harvesters. Following the first test series, field modifications were necessary to both of the machines to improve the cane quality and field performance. The second test series was marked by good to excellent milling, clarification, and boiling response. Delays between harvesting and milling of 5 and 6 days were incorporated into the cut-chop tests with negligible refractory processing results. Unfortunately, the second test series was conducted during cool weather associated with the latter stages of the crop - and deterioration of the cane billets was generally minimal. Based on these results, there is clearly an incentive to expedite further such tests, while at the same time evaluating the field performance of the machines. Particularly critical from the processing standpoint is the need for data during the early warm humid stages of the crop.

INTRODUCTION

The Problem

Since its inception, born of economic necessity, mechanical harvesting and handling of cane has contributed to inferior cane quality in Louisiana. The problem was recognized as early as 1946 and was the object of a study aptly titled "A Study of the Causes of Declining Sugar Recovery in Louisiana" (5). In these studies, a marked decline in factory sugar yield was associated with rapid progress in field mechanization resulting from labor shortages during and immediately after World War II. This and subsequent studies pointed up the need for close field supervision and field-factory coordination to assure fresh and relatively trash-free cane. The result has been an uneasy compromise between the requirements for economical field operations and the equally pressing need for reasonable cane quality.

Commencing with the 1970 crop, an increasing volume of trash in general - and field soil in particular - has been noted in the industry, and the 1972 crop witnessed a record 14.24 trash % cane. The field soil was clearly associated with larger heavy-duty piler-loaders and the inability in many areas to maintain proper loader supervision.

As to the standing cane quality, the outfield test data clearly show that the recoverable sugar is in the cane. The sugar is not appearing in the bag, and relative outfield test versus factory yield data indicate average losses of the order of 20 lb sugar per ton of cane as a conservative estimate.

Improved varietal yields and millions of dollars in factory modernization have contributed little if any to factory efficiency as indicated by the comparative tabulation of 1939-42 and 1970-73 crop average data (Table 1).

Table 1. Comparison of Louisiana sugarcane quality and factory performance 1939-42 and 1970-73.

Parameter	Time period	
	1939-42	1970-73
Pol % cane	10.10	9.75
Fiber 5 cane	13.50	15.82
Trash % cane	---	11.86
Normal juice: sucrose	12.35	12.44
purity	76.74	77.99
Pol extraction	91.48	88.08
Retention	86.90	83.89
Overall recovery	79.29	73.89
Yield, lb sugar raw value per		
Gross ton	168.1	150.9
Net ton	168.1	171.4
Tons cane per ton sugar, raw value	11.90	13.25

While the yield per net or trash-free cane is a common criterion of factory performance, it basically reflects only the yield per ton of cane paid for. The factory processes gross cane, and the factory loading is more realistically reflected in the yield per gross ton of cane - or gross tons of cane per ton of sugar. To the tabulated efficiency and yield losses must be added such factors as loss of sugar in washing the cane (before the chemical accounting starts), capacity limitations at the factory stations, additional capital equipment, and expenses associated with equipment maintenance and repair, auxiliary fuel, and pollution measures as disposal of cane wash water.

The current harvesting and handling system - like that for cane sampling - is in many respects an add on and modification to the system in effect with hand-cut cane. Louisiana practice is to mechanically harvest by whole-stalk harvesters (cutting top and bottom), transfer to the heap row, burn to remove the foliage, and transfer by means of piler-loaders to field carts.

The problem is clearly economic in its implications. During the years immediately preceding the 1974 crop, the Sugar Act target price merely enabled the Louisiana raw sugar industry to stay in business. For the processor it provided no incentive for new factories and necessitated stepwise expansion and modernization of existing factories due to limited capital availability. High prices during the 1974 crop provided a temporary reprieve, but have now been accompanied by corresponding increases in equipment costs, labor, and services.

A Possible Solution

Increased sugar yields offer the only long term avenue for increasing factory returns. These must come from improved harvesting and handling techniques. While efforts have been made to improve upon the current system - particularly in the piler-loader operations - it appears that the only workable solution will have to be a complete revision of the current harvesting scheme - whatever that change may be.

A comparative evaluation of the existing and new harvesting systems entails both field and factory costs and returns and includes among other things:

Field: Equipment costs and operating expenses, service factor, field losses as scrap, and the returns to the grower by way of the cane payment.

Factory: Equipment modifications to handle the cane, processing response at the factory stations, and returns to the factory in the income from sugar and molasses.

On an industry-wide basis, increased returns from sugar and molasses must be adequate to cover the additional costs in the field and factory. It is entirely possible that an increased field cost will have to be met by a change in the sharing relationship - or by the factory assuming the responsibility for harvesting and handling.

Processing Response Studies

Processing response studies entail observations on a factory - or semi-factory - scale of the operations at the mill, clarification, and crystallization stations. Bench-scale operations, while quite adequate for fractionation studies, i.e., juice, bagasse, syrup, sugar, and molasses quality, cannot provide critical operating data. The Audubon Sugar Factory procedure has been well tested in prior varietal evaluation studies and investigations into new equipment, chemicals, and processes. Only minor modifications have had to be made for these studies.

The 1973 studies were a continuation of those initiated in 1972 as part of an industry, U.S.D.A. Houma Experiment Station, and Audubon Sugar Factory cooperative study. In view of the increasing acceptance of the cut-chop combine harvester in other cane growing areas, interest centered on this system as modified for Louisiana conditions (10). The 1972 studies were quite limited in scope due to delay in getting a working combine harvester into the field. Similar problems were encountered in 1973; however, once initiated, the studies were much more comprehensive.

SCOPE OF THE STUDIES

General

These studies entailed the comparative processing response of 2 cut-chop combine-type harvesters with that of conventionally harvested whole-stalk cane. As originally conceived, there were to be 2 series of tests with each harvester - the tests covering (a) the warm humid early period of the crop and (b) the latter cool crop stages. Each test series was to include processing 24 hr after delivery and again 48 hr after delivery. As events transpired, parts delivery problems necessitated delaying the start of the tests. Additionally, numerous field-factory coordination problems required numerous modifications to the original processing schedule.

For each test, hand-cut samples (reflecting standing cane quality) and 2 to 3 ton consignments were collected. The conventionally harvested cane was cut and transferred to the heap row, burned, mechanically loaded, and delivered in slinged bundles. The cut-chop cane was combine harvested and loaded and delivered in 4 ft wide x 10 ft long x 8 ft 4 in. high expanded metal bins.

The hand-cut samples were topped, cleaned, and milled in the small Farrel hydraulically loaded mill under conditions simulating commercial scale milling severity. The 2 to 3 ton consignments were milled in the Factory Squier mill and the extracted juice processed to a first strike sugar and molasses in one of the 2 factory pilot plants.

Cane Quality and Processing Response

Of primary interest were data reflecting (a) the different harvesting techniques and (b) the effect of delay between harvesting and processing with each harvesting scheme. Comparative criteria were (a) cane quality and (b) processing response.

Cane Quality: Cane quality was viewed from the standpoint of extracted juice inspections and calculated cane quality parameters. Mixed juice quality included the reducing sugars ratio, gum and dextran content, and the juice purity. Cane quality parameters were trash, pol, and Brix % Cane - and the predicted 96° sugar yield as calculated from the actual mill extraction, the Winter-Carp retention formula, and an assumed 96.00 boiling house efficiency.

Processing Response: The following criteria were used to reflect the operations at the successive stations of milling, clarification, and crystallization:

Millability (ease of milling and the absence of mill chokes), bagasse pol and moisture, and pol extraction. (Subsequent to these tests, grinding rate as tons of cane per hour has been added.) While a typical run may last only 10 to 12 minutes, this time has proved adequate to qualitatively evaluate the mill performance under normal circumstances.

Clarified juice quality as light transmission and mud volume after two hours settling time.

A good sugar boiler is essential, since such judgement aspects are involved as quality of the boiling massecuite, the apparent rate of crystal growth, and the appearance of the crystals. Additionally, such quantitative aspects were considered as sugar pol, and the A strike sugar yield as calculated by the SJM formula on a solids basis. This necessitated several sugar moisture determinations for subsequent sugar purity calculations.

EQUIPMENT

Harvesting

The cut-chop harvester designated as A was a 2-row harvester with sticker gathering chains, circular cutting blades and dual topping blades for each row, 8 cross flow sickle bar choppers on a circular drum configuration, a blower for trash separation, and a screened drum with suction fans for trash removal.

Cut-chop harvester B was a single row harvester with scroll-type row dividers, dual circular cutting and topping blades, vertically mounted circular chopping blades, and induced draft blowers at the junction of the inclined and cross conveyors and at the point of discharge.

Processing

Farrel Sample Mill: This 3-roll (12 in. dia. x 12 in. long rolls) mill is powered with a 15 HP variable speed motor drive assembly and includes a hydraulic system capable of delivering up to 40 tons per foot of roll length.

Factory and Pilot Plant: The factory cane handling facilities consist of a 4-ton American steel guy derrick, an inclined feeder table, and a 4-feet wide secondary steel slat carrier feeding the main carrier.

The Squier milling tandem is made up of a 20 in. by 24 in. Fulton-type 2-roll crusher, followed by 3 triangular stress 18-1/2 by 24 in. 3-roll mills. The individual milling units are each driven by a direct current motor through double reduction Falk gearing. Roll pressures are maintained by Edwards Accumulators at the ends of the top roll of each mill.

Weighing and measuring facilities include a Howe derrick scale to weigh the cane, a mixed (extracted) juice tank on a platform scale for the juice weight, a large wooden bin on a Buffalo scale for the bagasse, and a rotameter for maceration water rate and a volumetric meter for the measured volume.

The first floor pilot plant juice processing facilities consist of two 100-gal cone-bottom liming tanks equipped with mixers, a heater charge pump, 2 Ross shell and tube heat exchangers, and five 100-gal open clarifier tanks with juice draw-off lines at different elevations. The clarified juice is evaporated to syrup in a forced circulation evaporator having 11.75 sq ft of heating surface.

The third floor crystallization station consists of 2 calandria-type vacuum pans of about 10-gal capacity and a Bird centrifugal operating at about 1750 rpm. The pans are served by shell and tube condensers, a vacuum pump system, thermistors for pan temperature, absolute pressure indicators for pan pressure, conductivity meters for saturation control, and a massecuite mobility probe (on one pan).

PROCEDURE

Harvesting

The conventionally-harvested cane was cut with a typical Louisiana whole-stalk harvester, burned, mechanically loaded, and delivered in 2-3 ton slinged bundles. The cut-chop cane was either loaded directly into the bins or subsequently transferred to the bins. Accompanying the conventional and cut-chop cane was a 100-lb sample of hand-cut cane from the same plot.

As originally conceived, the cane delivery for a test series was to consist of sufficient material for 2 conventional and 2 cut-chop runs to be made at varying intervals from the time of cutting - and the 100 lb sample. As actually implemented, the higher than anticipated bin density permitted more than 2 cut-chop runs on occasion. In the case of Machine B, Series 2, the conventionally-harvested cane was inadequate for a factory run.

Processing

100 lb. Samples: The samples were hand cleaned and topped above the top ripe joint. About 100 lb of the cleaned and topped sample were weighed and milled in the Farrel mill. Commercial milling severity was simulated by passing the cane through the mill 4 times with the addition of about 20% maceration water (1/2 after the first pass and 1/2 after the second pass). Cane, water, juice, and bagasse were measured or weighed - and samples of juice and bagasse were analyzed.

Factory and Pilot Plant: At the factory, the cane was weighed and transferred to the feeder table and a 100-lb sample removed for trash determination. The cane consignment was then processed in the factory mill with 20% maceration water and a last mill roll speed of about 30 ft per min. Samples of crusher, mixed and last roll juice and bagasse were collected and sent to the laboratory for analysis.

Following a mill run, the mixed juice was pumped to the pilot plant where it was treated with about 100 ppm as P_2O_5 of 85% phosphoric acid, limed to 7.5 to 7.6 pH, heated to 220 F and treated with 2 ppm of Separan AP-30 prior to settling in the clarifier tanks. (The use of phosphoric acid is common practice for such test runs due to the wide variation in varieties and cane quality which we encounter.) On the first run of a series, it was standard practice to verify in the laboratory the juice treating and clarification conditions. Based on the laboratory observations, the recommended phosphoric acid treatment and limed juice pH were determined and reported to the pilot plant operators.

After about 2 hr, the supernatant or clarified juice was liquidated by gravity to the evaporator charge tank. The final concentration to a 60° brix syrup was done in the forced circulation evaporator.

The boiling scheme included a grain strike and an A strike. The grain strike was pan seeded with fondant sugar and brought up to strike volume. The pan was subsequently discharged leaving sufficient footing to cover the calandria - upon which the A strike was boiled. The subsequent massecuite was purged in the centrifugal. No water was added to the centrifugal to improve sugar quality since one criterion of crystallization response was the purity cut-out between massecuite and molasses.

At the conclusion of the various processing stages, samples of clarified juice, syrup, massecuite, sugar and molasses were collected for analysis.

Analyses

Brix was by hydrometer and pol by the direct polarization method. With the exception of gums, dextran, and clarified juice light transmission, the standard raw-sugar-factory analytical procedures were followed. Pol in bagasse was determined by hot digestion and fiber calculated by difference, i.e., 100 - (brix + moisture). Reducing sugars in juice were determined by the Lane and Eynon volumetric method.

Clarified juice clarity was determined as the % light transmittance in an Instratech Model T-600 spectrophotometer at 600 mu. The instrument was calibrated to read 100% transmittance with distilled water.

Gums and dextran determinations were made on all mixed juice samples. Procedural techniques are summarized in the Appendix.

RESULTS

General Observations

Parts procurement problems delayed implementation of the tests. For this reason, only one test was made during the latter part of October while the weather was still warm and humid. The remaining tests were conducted during relatively cool weather.

Minimal adhering stubble was observed with both the whole and the cut-chop cane. Additionally, the whole-stalk cane was generally free of field soil. This probably reflected the selective loading of the 2 to 3 ton whole-stalk consignments as compared to the piling (and dozing) associated with the commercial-scale piler-loader operations.

With the exception of the variety L 60-25, good milling quality was observed for both the conventional and the cut-chop harvested cane. It was possible to maintain relatively high last roll speeds of the order of 7.6 to 9.0 rpm without choking. As noted previously, in subsequent such tests, we are now determining the grinding rate as tons/hr. Generally, pol % bagasse was high, reflecting the limited tandem length.

Cut-chop mill-juice quality was superior, being free of soil and crush-crush and comparable in visual quality to that from the factory sample mills. Bagasse was light in color, indicating the absence of any appreciable quantity of field soil. Bagasse from a subsequent Harvester B test analyzed 5.79% ash on dry solids as compared to commercial factory data ranging from 6 to 23%.

Cut-chop billets were selected at random from each load and analyzed for length and billet damage. These data are summarized in Table 2.

Table 2. Cut-chop billet quality.

Parameter	Harvester and series			
	A		B	
	1	2	1	2
No. billets surveyed	20	15	23	26
Ave. length of billets (in.)	18.9	16.4	13.2	14.1
% clean cut	--	53	48	54
% frayed or bruised	--	47	52	46

Relative to billet density, each 4 ft x 10 ft x 8 ft 4 in. bin held sufficient cane for a 2 to 3 ton run. The average billet density - with about 1 ft freeboard to the top - was about 17 lb/cu ft. This was in marked contrast to the previous year's run with Machine B with the chopping blades set for 20 in. billets - and a typical bin held about 1 ton of cane. However, the longer billets were uniformly cleancut with a minimum of spooling or fraying. Thus shortening the billet length increased load density but at the expense of billet damage.

Cane Quality

The test conditions and cane quality are summarized in Tables 3 and 4.

Table 3. Comparison of cane quality - conventional versus combine harvester A.

Parameter	Variety, series, and run									
	1					2				
	CP 61-37(S)					CP 61-37(S)				
	100 lb sample	Whole-stalk		Cut-chop		100 lb sample	Whole-stalk	Cut-chop		
		1	2	1	2		1	1	2	3
Date		10/31	11/2	11/01	11/02		12/05	12/04	12/06	12/07
Days after cutting		3	4	1	2		3	1	3	4
Temperature (°F)		64	70	60	70		50	61	48	42
% Cane: Trash	0	6.0	9.1	14.0	21.0	0	12.0	9.0	9.0	-
Brix	11.41	13.72	14.84	13.73	13.39	14.01	13.38	13.18	13.61	-
Pol	9.24	9.87	10.26	9.52	8.76	11.85	10.43	10.71	11.05	-
Fiber	10.95	11.70	13.17	12.65	12.58	11.81	13.67	13.14	13.68	-
Normal juice:										
Sucrose	-	11.95	11.61	10.54	9.75	-	12.17	12.69	12.66	-
Purity	-	74.25	69.97	69.74	66.06	-	78.51	82.09	81.69	-
Mixed juice:										
Purity	80.85	74.25	69.97	69.74	66.06	84.64	78.51	82.09	81.69	80.53
RS ratio	9.44	12.94	16.97	14.72	15.44	7.16	8.00	6.99	7.92	7.93
Gums % brix	0.56	0.53	0.79	0.81	1.00	0.65	0.70	0.78	0.89	0.94
Dextran % brix	0.10	0.15	0.16	0.21	0.55	0.08	0.18	0.12	0.15	0.17
Pol extraction	92.25	91.68	90.68	90.56	90.63	90.89	89.20	89.15	88.37	-
Yield (lb, 96° sugar):										
per gross ton	154.3	155.3	154.1	142.5	126.2	199.8	165.7	174.3	177.8	175.0 (e)
per net ton	154.3	165.2	169.5	165.7	159.7	199.8	188.3	191.5	195.4	
per standard ton	--	167.4	185.1	211.9	258.9	-	181.9	173.1	177.6	

Table 4. Comparison of cane quality - conventional versus combine harvester B.

Parameter	Series and variety						
	100 lb sample	1			2		
		CP 36-13(P)			L 60-25(P)		
		Whole- stalk	Cut-chop		100 lb sample	cut-chop	
		1	1	2		1	2
Run		11/29	11/29	12/03		12/17	12/19
Date		3	1	5		4	6
Days after cutting		52	52	70		37	57
Temperature (°F)		52	52	70		37	57
% cane: Trash	0	6.0	6.0	-	0	11.0	10.0
Brix	14.67	14.43	14.43	-	15.90	15.59	15.47
Pol	12.67	11.89	11.88	-	14.25	12.55	12.25
Fiber	12.26	14.06	13.27	-	11.64	14.02	15.62
Normal juice: Sucrose		14.16	14.02	13.67		14.43	14.60
Purity		82.83	82.72	80.08		80.94	79.72
Mixed juice: Purity	86.35	82.83	82.72	80.08	89.62	80.94	79.72
RS ratio	4.51	4.48	5.86	7.75	1.21	2.94	2.80
Gums % brix	0.47	0.57	0.56	1.21	0.51	0.77	0.60
Dextran % brix	0.08	0.17	0.08	0.36	0.10	0.20	0.14
Pol extraction	93.76	91.34	91.37	-	89.62	88.40	85.70
Yield lb 96° Sugar							
per gross ton	222.6	199.2	199.0	191.4(e)	243.6	201.0	188.6
per net ton	222.6	211.9	211.7	-	243.6	225.8	209.6
per standard ton	--	171.5	173.3	-	-	181.1	168.2

Harvester A (Series 1): As indicated by the juice purity and reducing sugars ratio, this cane was relatively immature at the time of the test, October 28 through November 1. A high volume of tops and suckers accompanied the cut-chop cane. This in turn was reflected by a correspondingly high mixed juice gum and dextran content and low juice purity. For both test series, a 24-hr delay between the 2 whole-stalk and the 2 cut-chop runs appears to have contributed to a decrease in cane quality. However, the interfering effect of extraneous material makes it difficult to evaluate this factor for the cut-chop cane.

The 100-lb sample data are the average of 2 runs. Other than an error in sample selection, there is no explanation for the low pol % cane and correspondingly low predicted yield.

Harvester A (Series 2): The combine-harvester topping mechanism was modified for this test series. Unfortunately, only one whole-stalk bundle accompanied this delivery; however, excellent bin density permitted 3 instead of 2 cut-chop runs. Since the latter run was made 4 days after cutting, primary interest centered on the boiling house response - and no material balance data were taken around the mill.

In reviewing the data, it is evident that this variety matured considerably in the one month interval between tests. Mixed juice purity was excellent for all cut-chop runs. As would be expected there was an increase in reducing sugars, gums, and dextran with time. The magnitude of the increase was considered to be of a relatively small order.

Harvester B (Series 1): Operating problems with this harvester delayed testing until late in November. Because of this, only one whole-stalk and one cut-chop run were planned. However, higher than anticipated bin density permitted scheduling 2 cut-chop runs. In order to release the bins, the second run material was dumped on the feeder table on Friday, covered with plastic, and processed Monday - a delay between cutting and harvesting of 5 days.

While it was not evident at the factory, field reports indicated that the combine harvester cut high, leaving an unnecessarily high volume of stubble in the field.

Excellent cane quality with correspondingly high predicted yields is evident for both the whole-stalk and first cut-chop run. A marked increase in gums and dextran is noted during the 4-day period preceding the second cut-chop run. As noted in a later section, this did not appear to greatly affect the processing response - particularly crystallization.

Harvester B (Series 2): For this series, the combine-harvester bottom blades were properly positioned. Unfortunately only cut-chop cane was included in the harvest schedule. Since the cane was cut Thursday and delivered Friday afternoon, runs were scheduled Monday and Wednesday (4 and 6 days after cutting).

Despite some freeze damage of the tops - and the extended delay between cutting and harvesting - excellent cane quality is evident in all the criteria of reducing sugars, gums, dextran, and predicted yield. There is no doubt that the cool weather contributed to the superior keeping quality of this cane after cutting.

Processing Response

General: In evaluating processing response, it is impossible to neglect the associated parameter of cane quality. For this reason, the complete data for the 4 series of runs are shown in the Appendix under the following tabular headings:

- Table A-1. Combine Harvester A, series 1
- Table A-2. Combine Harvester A, series 2
- Table A-3. Combine Harvester B, series 1
- Table A-4. Combine Harvester B, series 2

Harvester A (Series 1): Immature cane and the high volume of leafy foliage, tops, and suckers accompanying the cut-chop cane probably contributed to the high moisture in bagasse. These factors are also reflected in the poor clarified-juice light transmission and high clarifier mud volume. Poor pan circulation was noted with both the whole-stalk and the cut-chop cane. No attempt was made to boil to sugar the second cut-chop run.

Harvester A (Series 2): Changes to the combine harvester topping mechanism caused a marked improvement in processing response. In terms of bagasse quality, a higher pol in bagasse is noted for the cut-chop runs. Obviously there are limits to what can be done with an 11-roll tandem and such observations must be relative. The second cut-chop run was pushed to a roll speed of 9 rpm with no mill feeding or choking problems. This may have accounted for the higher bagasse pol and moisture. Poorer clarified-juice light transmission and a slightly higher mud volume were observed for the cut-chop runs. Boiling response was excellent for all runs, with good grain quality and rapid grain growth.

Harvester B (Series 1): The processing response for the first whole-stalk and cut-chop runs was almost identical. Milling response was good and clarification and boiling response superior. A varietal characteristic appears to be an almost water white clarified juice with a sparkling luster.

Particular interest centered on the boiling house response of the second cut-chop run (5 days after cutting) in view of the 2-fold increase in gums and 5-fold increase in dextran. Despite this, clarification response was good with the exception of a slight haze in the clarified juice. Despite some grain elongation (associated with higher dextran content), massecuite mobility and grain growth were excellent. The 95.0 sugar pol is misleading, since a subsequent inspection of the sugar showed a good luster. Apparently the drying cycle on the centrifugal was too short, resulting in a correspondingly high moisture.

Harvester B (Series 2): Field scheduling problems resulted in only 2 deliveries of cut-chop cane - arriving late Friday afternoon. The runs were made Monday and Wednesday (4 and 6 days after cutting). Numerous mill chokes were encountered (a varietal characteristic) with a correspondingly high bagasse pol and poor extraction. Clarification response was good and boiling response excellent in terms of massecuite mobility and grain growth. No rectangular grain was observed despite the delay in processing - a factor undoubtedly due to the prevailing cold weather.

The Dextran Standard Curve

Considerable effort was spent in comparative studies of the dextran standard curve, which was prepared from a commercially available dextran, and similar curves prepared from naturally occurring dextran isolates (3). In summary, the standard curve for dextran content was prepared

from a commercially available dextran (MW 15,000 to 20,000) manufactured by the Nutritional Biochemical Corp. Dextran strains A, D, and F were isolated from the cane juice. Similar strains were identified in Egan's investigations (1). Comparative standard curves with these strains and the commercial material showed increasing slope with apparent molecular weight, the steepest slope being that for the commercial dextran. Within the normal dextran range of 0.1 to 0.4 mg/ml dextran in juice, errors in interpreting dextran content using the standard curve instead of that for any of the 3 strains were of the order of 17, 35, and 44% for strains F, D, and A respectively. Clearly, a lower molecular-weight commercial dextran would have been preferable if such had been available. Additionally, it is evident that comparison of dextran content among different cane growing areas requires agreement as to the dextran to be used for the standard curve.

CONCLUSIONS

General

These investigations were marked by several constraints to include temperature, humidity, and the number and types of runs made. Temperatures were generally low, and the temperature and humidity for the four weekly runs averaged 62, 55, 52, and 45 F and 69, 67, 65, and 63%, respectively. Additionally, there were inadequate whole-stalk runs to conclusively interpret cane quality and processing response as a function of time delay between cutting and milling. Finally, following the first run series with each harvester, some major modifications to the equipment were made to improve the performance in the subsequent test series.

As a final (and most important point), the major deficiencies in the current whole-stalk system are in the areas of (a) loading - with the high field soil volume common to the piler-grab loading, (b) field coordination to ensure prompt delivery of the cut and burned cane to the factory, and (c) storage in the factory yard. The tailored conditions for these investigations included loading by grab without the piling or dozing common to commercial operations; closely supervised scheduling of the cutting, burning, and delivery; and yard storage in individual slinged bundles rather than in a pile common to the factories.

In essence, if the test conditions prevailed commercially there would be no need for the current investigations into alternative harvesting techniques.

Specific Conclusions

1. Other than Series 1 for Harvester A, there was no significant difference in cane quality and processing response between the first comparative whole-stalk and cut-chop runs.

2. For the cut-chop cane, an increase in gums and dextran was associated with the time delay between runs. In one case (under the most rigorous conditions where the cane was spread on the feeder table over the weekend - Harvester B, Series 1) the gum and dextran content increased 130 and 111%, respectively, over the 4-day interim between the first and second milling, with final gum and dextran concentrations of 1.209 and 0.355% brix. Although grain elongation was noted, boiling response was excellent. Unfortunately, time did not permit the preferred practice of carrying the boiling through to a 3-strike system. Several authors have cited a high degree of correlation between dextran content and molasses exhaustibility (2, 6, 11). Attempts have been made to establish threshold dextran concentrations above which poor processing response would be anticipated. Salazar (10), using the same processing scheme in the 1972 studies, cited a threshold concentration of 0.25 dextran % brix. While concentrations for the first cut-chop runs were well under this figure, it was exceeded in two cases in subsequent runs with no apparent serious processing problems.

3. At the clarification station, the cut-chop cane exhibited a lower clarified-juice light transmission but correspondingly lower mud volume than the comparative whole-stalk runs.

4. As regards appearance and the absence of cush-cush in the juice, the cut-chop cane extracted juice and bagasse quality approximated that of hand-cut cane. It is the opinion of the authors that the large volume of cush-cush commonly observed in the factories reflects the effect of deterioration of the foliage accompanying the cane. Observations at the Audubon Sugar Factory indicate that there is a minimal volume of cush-cush with fresh cane. Apparently, deteriorated foliage crumbles and disintegrates under mill pressure.

RECOMMENDATIONS

1. There is a clear incentive for expediting the development of cut-chop harvesters applicable to Louisiana conditions.
2. Further processing studies should be conducted early in the crop under the warm humid conditions associated with this time of the year.

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APPENDIX

Analytical Procedures

Gums: Gums were determined using the alcohol precipitation method of Roberts and Friloux (9). The method is based on hydrolysis of the gums to simple sugars and the reaction of the pentose and hexose sugars with a phenol-sulfuric acid reagent. The results are expressed quantitatively by means of photocolormetric determinations. The gums so determined contain polysaccharides normal to sound cane as well as decomposition products.

Briefly, the method involves the removal of starch by centrifuging at 3000 rpm, precipitation from the supernatant liquid of the gums by ethyl alcohol and centrifuging, resolution of the separated gums by water, and the hydrolysis and reaction of the subsequent pentose and hexose sugars with phenol in sulfuric acid. The % transmittance of the solution is measured in a Bausch and Lomb Model 20 spectrophotometer at 485 mμ and the concentration of the gums is determined by reference to a glucose standard curve. The concentration of the gums is expressed as mg of gums per 10 ml of juice.

Dextran: Dextran in juice was determined using the haze method of Nicholson and Horsley (8), as modified by Keniry, Lee, and Mahoney (7). The method involves the removal of the protein from the juice with trichloroacetic acid, filtration with filter aid, addition of ethyl alcohol, and reading the absorbance of the solution in a Bausch and Lomb Model 20 spectrophotometer at 720 mu after standing for 20 min. The dextran concentration was determined from a dextran standard curve which was prepared with a 15,000-20,000 MW dextran (Nutritional Biochemical Corporation) and expressed as mg dextran per ml juice.

Table A-1. Combine harvester A, series 1: Processing response of conventional whole-stalk versus cut-chopped harvested cane.

Variety: CP 61-37(S)
Week: October 29

<u>Harvest schedule</u>		<u>Whole-stalk</u>	<u>Cut-chop</u>			
Cut		10/28	10/31			
Burn		10/29				
Deliver		10/30	10/31			

Run	100 lb sample	<u>Factory</u>			
		<u>Whole-Stalk</u>		<u>Cut-chop</u>	
		1	2	1	2
Date	-	10/31	11/02	11/01	11/02
Days after cutting	-	3	4	1	2
Temperature, °F (mean)	-	64	70	60	70
% cane: Trash	0	6.0	9.1	14.0	21.0
Maceration	25.00	19.24	19.65	23.05	91.44
Mixed juice	102.20	91.14	89.68	92.59	91.44
Bagasse	23.30	28.11	29.97	30.46	30.61
Brix	11.41	13.72	14.84	13.73	13.39
Pol	9.24	9.87	10.26	9.52	8.76
Fiber	10.95	11.70	13.17	12.65	12.58
Normal juice: Brix	-	16.70	16.59	15.12	14.76
Sucrose	-	11.95	11.61	10.54	9.75
Purity	-	74.25	69.97	69.74	66.06
Crusher juice: Brix	-	16.60	17.10	15.59	15.52
Purity	-	77.37	74.40	73.70	73.26
Mixed juice: Brix	10.33	13.32	14.82	13.35	13.14
Pol	8.35	9.89	10.37	9.37	8.68
Purity	80.85	74.25	69.97	69.74	66.06
RS ratio	9.44	12.94	16.97	14.72	15.44
Gums % brix	0.56	0.53	0.79	0.81	1.00
Dextran % brix	0.10	0.15	0.16	0.21	0.55
Last roll juice: Brix	-	7.18	6.80	5.92	6.21
Purity	-	71.73	66.00	65.90	59.74
Bagasse: Moisture	49.20	52.70	50.90	54.00	54.40
Pol	3.00	4.04	3.19	2.95	2.68
Fiber	47.00	41.62	43.94	41.52	41.11
Pol extraction	92.25	91.37	90.68	90.56	90.63
Clarification response					
Clarified juice purity	-	78.30	73.98	74.16	72.10
Light transmission, %	-	24	20	16	5
Mud volume	-	32	25	30	31

Table A-1. Continued

Run	100 lb sample	Factory			
		Whole-stalk		Cut-chop	
		1	2	1	2
Crystallization response					
Syrup purity	-	78.93	74.66	74.67	73.24
Sugar pol	-	96.1	-	94.3	-
A strike yield, % solids	-	51.75	-	48.03	-
Yield, lbs. 96° Sugar/ton ¹	154.3	155.3	154.1	142.5	126.2
net	154.3	165.2	169.5	165.7	159.7
standard	-	167.4	185.1	211.9	258.9

¹ Assume actual extraction and 96.00 B.H.E.

Table A-2. Combine harvester a, series 2: Processing response of conventional whole-stalk versus cut-chopped harvested cane.

Variety: CP 61-37(S)

Week: December 3

Harvest schedule		Whole-stalk	Cut-chop
Cut		12/02	12/03
Burn		12/03	
Deliver		12/03	12/03

Run	100 lb sample	Factory			
		Whole-stalk	Cut-chop		
		1	1	2	3
Date		12/05	12/04	12/06	12/07
Days after cutting		3	1	3	4
Temperature, °F (mean)		50	61	48	42
% cane: Trash	0	12.0	9.0	9.0	-
Maceration	20.00	18.58	20.16	20.74	-
Mixed juice	91.75	87.48	90.19	88.92	-
Bagasse	27.72	31.10	29.97	31.82	-
Brix	14.01	13.38	13.18	13.61	-
Pol	11.85	10.43	10.71	11.05	-
Fiber	11.81	13.67	13.14	13.68	-
Normal juice: Brix	-	15.50	15.46	15.50	
Sucrose	-	12.17	12.69	12.66	-
Purity	-	78.51	82.09	81.69	-
Crusher juice: Brix	-	15.98	15.94	15.98	
Purity	-	81.41	83.56	82.60	
Mixed juice: Brix	13.87	13.54	12.90	13.44	13.46
Pol	11.74	10.63	10.59	10.98	10.84
Purity	84.64	78.51	32.09	81.69	80.53
RS ratio	7.16	8.00	6.99	7.92	7.93
Gums % brix	0.65	0.70	0.78	0.89	0.94
Dextran % brix	0.08	0.18	0.12	0.15	0.17
Last roll juice: Brix	-	6.90	6.62	6.60	
Purity	-	73.48	75.22	77.42	

Table A-2. Continued

Run	100 lb sample	Factory			
		Whole- stalk 1	Cut-chop		
			1	2	3
Bagasse: Moisture	52.80	51.10	51.00	51.80	-
Pol	3.90	3.62	3.88	4.04	-
Fiber	42.59	43.97	43.84	42.98	-
Pol extraction	90.89	89.20	89.15	88.37	-
Milling response Tons/hour	-	14.97	15.16	-	-
Clarification response					
Clarified juice purity	-	81.89	81.77	82.65	80.03
Light transmission, %	-	32	11	22	25
Mud volume	-	14	15	15	15
Crystallization response					
Syrup purity	-	81.93	82.44	83.42	83.59
Sugar pol	-	96.8	96.3	96.6	-
A strike yield, % solids	-	59.13	55.83	55.98	-
Yield, lb 96° sugar/ton ¹					
gross	199.8	165.7	174.3	177.8	175.0(e)
net	199.8	188.3	191.5	195.4	-
standard	-	181.9	173.1	177.6	-

¹Assume actual extraction and 96.00 B.H.E.

Table A-3. Combine harvester B, series 1: Processing response of conventional whole-stalk versus cut-chopped harvested cane.

Variety: CP 36-13(P)
Week: November 26

Harvest schedule		Whole-stalk	Cut-chop	
Cut	11/26		11/28	
Burn	11/27			
Deliver	11/28		11/28	
		Factory		
Run	100 lb sample	Whole- stalk 1	Cut-chop	
			1	2
Date	-	11/29	11/29	12/03
Days after cutting	-	3	1	5
Temperature, °F (mean)	-	52	52	70
% cane: Trash	0	6.0	6.0	-
Maceration	18.60	20.70	21.95	-
Mixed juice	93.90	90.84	92.57	-
Bagasse	24.70	29.87	29.38	-
Brix	14.67	14.43	14.43	-
Pol	12.67	11.89	11.88	-
Fiber	12.26	14.06	13.27	-
Normal juice: Brix	-	17.10	16.95	17.07
Sucrose	-	14.16	14.02	13.67
Purity	-	82.83	82.72	80.08

Table A-3. Continued

Run	100 lb sample	Factory		
		Whole- stalk	Cut-chop	
		1	1	2
Crusher juice: Brix	-	17.63	17.47	17.60
Purity	-	84.57	84.14	82.84
Mixed juice: Brix	14.65	14.44	14.24	14.56
Pol	12.65	11.96	11.78	11.66
Purity	86.35	82.83	82.72	80.08
RS ratio	4.51	4.48	5.86	7.75
Gums % brix	0.47	0.57	0.56	1.21
Dextran % brix	0.08	0.17	0.08	0.36
Last roll juice: Brix	-	6.50	6.70	-
Purity	-	78.15	78.06	-
Bagasse: Moisture	46.70	48.50	50.60	-
Pol	3.18	3.45	3.32	-
Fiber	49.62	47.09	45.15	-
Pol extraction	93.76	91.34	91.37	-
Milling response Tons/hour	-	-	-	-
Clarification response				
Clarified juice purity	-	85.80	85.50	81.33
Light transmission, %	-	52	50	44
Mud volume	-	18	15	15
Crystallization response				
Syrup purity	-	85.07	84.91	82.94
Sugar pol	-	96.9	97.5	95.0 ²
A strike yield, % solids	-	66.08	52.44	59.95
Yield, lb 96° sugar/ton ¹				
gross	222.6	199.2	199.2	191.4(e)
net	222.6	211.9	211.7	-
standard	-	171.5	173.3	-

¹Assume actual extraction and 96.00 B.H.E.

²Excellent sugar quality but moist - inadequate drying time.

Table A-4. Combine harvester B, series 2: Processing response of conventional whole-stalk versus cut-chopped harvested cane.

Variety: L 60-25(P)
Week: December 17

Harvest Schedule	Whole-stalk	Cut-chop
Cut	-	12/13
Burn	-	12/14 (Friday)
Deliver	-	

Table A-4. Continued

Run	100 lb sample	Factory	
		Cut-chop	
		1	2
Date	-	12/17	12/19
Days after cutting		4	6
Temperature, °F (mean)		37	57
% cane: Trash	0	11.0	10.0
Maceration	19.30	29.62	25.40
Mixed juice	92.20	96.08	89.05
Bagasse	27.10	33.54	36.35
Brix	15.90	15.59	15.47
Pol	14.25	12.55	12.25
Fiber	11.64	14.02	15.62
Normal juice: Brix	-	17.83	18.31
Sucrose	-	14.43	14.60
Purity	-	80.94	79.72
Crusher juice: Brix	-	18.38	18.88
Purity	-	85.96	85.43
Mixed juice: Brix	15.71	14.27	14.79
Pol	14.08	11.55	11.79
Purity	89.62	80.94	79.72
RS ratio	1.21	2.94	2.80
Gums % brix	0.51	0.77	0.60
Dextran % brix	0.10	0.20	0.14
Last roll juice: Brix	-	8.51	8.61
Purity	-	77.44	76.07
Bagasse: Moisture	51.80	52.60	50.70
Pol	4.70	4.34	4.82
Fiber	42.96	41.80	42.96
Pol extraction	89.62	88.40	85.70
Milling response			
Tons/hour	-	-	-
Clarification response			
Clarified juice purity	-	85.92	84.30
Light transmission, %	-	22	31
Mud volume	-	14	15
Crystallization response			
Syrup purity	-	86.76	85.78
Sugar pol	-	96.8	97.0
A strike yield, % solids	-	56.52	47.59
Yield, lb 96° sugar/ton ¹			
gross	243.6	201.0	188.6
net	243.6	225.8	209.6
standard	-	181.1	168.2

¹ Assume actual extraction and 96.00 B.H.E.

USING BAGASSE AS FUEL

Victor J. Bailliet
Caldwell Sugars, Inc.
Thibodaux, Louisiana

It appears to me that the title of this paper should more appropriately be: Changes in the boiler room to improve the bagasse burning and reduce to a minimum the dependency on auxiliary fuel.

In the last few years many changes in the operating conditions of sugar factories have greatly affected the operation of the boilers.

Compliance with the air and water pollution control rules have necessitated the installation of fly ash arrestors and induced draft fans, generally requiring steam turbines drives, with an average of 200 HP per boiler. Recycling and cooling of the condenser water required the installation of extra pumps to take care of the greatly increased water volume and the cooling sprays feed.

This equipment in an average 3500 tons cane/day factory capacity has added a load of more than 1500 HP, and when all the power is provided by steam, a very serious increase in its demand has occurred, representing the production of an extra boiler and creating a significant excess of exhaust steam.

The increase in trash and mud content of the cane brought to the factories, which, despite a generally improved cane washing efficiency, has created more problems in the burning of the bagasse, with its higher ash content and lower heating value.

To crown all these problems, there are the fuel shortage and the tremendous price increase in fuel, with some contracts already negotiated at over \$1.25 per MCF of natural gas. If the gas is not available, its substitution by liquid fuel will be even more expensive.

All of these problems focus more attention on the necessity of burning bagasse as fuel - more of it and more efficiently.

In Louisiana it has always been a fact that the factories have generally enough boiler capacity but not enough furnaces, and this is even more true with the increased difficulty of burning muddy bagasse, despite a general trend of preheating the forced draft air to achieve a better combustion.

It is also possible that the high cost of fuel and its scarcity will make the bagasse much less attractive for industrial use at the cost of replacement fuel value. Then it would become interesting to consider a more efficient production and use of steam to create a surplus of bagasse which would have the double purpose of providing another source of revenue and assuring a lesser need for supplementary fuel.

Various means are available for achieving this goal:

Installation of boiler feed water heater deaerators increasing substantially the boiler efficiency and absorbing an otherwise excess exhaust steam.

The use of air preheaters in the flue gases path would also increase the boiler efficiency and bagasse burning ability. Unfortunately, this equipment is expensive.

Drying the bagasse using flue gases has been advocated; it would greatly improve its heating value and ability to burn, but no practical and economical system has been devised so far, to my knowledge.

All factories should have a good conveying system for carrying and storing excess bagasse with the ability to reclaim and return it to the boilers promptly, when needed.

In order to reduce the steam demand, increase the working steam pressure to the maximum boiler pressure allowable and when installing new higher pressure boilers in place of the remaining lower pressure old ones, consider a 2 live steam pressure system using 2 steam headers with an interconnecting pressure reducing valve to balance the load. Of course, the repartition of the prime movers and other steam users must be done in relation to the steam production of each generator group. This system has been in use successfully in a few sugar factories.

The exhaust steam pressure should, when possible, be lowered and maintained to the maximum pressure normally used in pans and evaporators.

This combination should reduce substantially the consumption of the prime movers closing hand valves or changing steam nozzles to maximize the efficiency of the steam turbines and consequently reduce the boilers load.

If with all these improvements, a persistent shortage of exhaust steam appears then the use of a pre-evaporator would be recommended to save make-up steam.

Some factories, in view of the reduction of gas consumption, have shifted the load from steam turbines to electric motors fed by purchased electric power. This solution in the long run is not economical because the price of electricity will increase with the fuel cost and finally does not result in any saving of energy.

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PROCEEDINGS

American Society
of
Sugar Cane Technologists

1975 MEETINGS

Volume 5 (New Series)

Florida and Louisiana Divisions

ASSCT

August 1976

P R O C E E D I N G S
A M E R I C A N S O C I E T Y
O F
S U G A R C A N E T E C H N O L O G I S T S

Florida and Louisiana Divisions

VOLUME 5 (NEW SERIES)

August 1976

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FOREWORD

Within the next three months the editors of the Proceedings and the editorial committee of ASSCT hope to have available for distribution to all members a style manual which will provide, in some detail, procedures, format, etc. for the preparation of manuscripts of papers to be published in the Proceedings. These procedures will be those that have been followed by the editors in recent volumes of the Proceedings. Until this manual is available, it will be very helpful in the editing and typing of the Proceedings if each author will examine closely a recent volume of these Proceedings and follow the style, format, system of abbreviation, etc. in writing papers.

Some authors who are familiar with the system of sending galleyproof to the authors for checking prior to publication, which most technical journals use, probably wonder why this system has not been adopted for the ASSCT Proceedings. The reason is of a practical nature. Each manuscript is retyped onto special over-size paper. It would add greatly to the cost of the Proceedings if the retyped copy of each paper was reproduced and sent to the author. We have been struggling to keep the cost of publishing the Proceedings at a modest level and have felt that the Society should not have to bear more than absolutely essential costs of publication. However, the system being used has led to some regrettable errors in the Proceedings which could have been corrected by sending copies of the typed manuscript to authors for proofreading. This matter should probably be submitted to the executive committee of ASSCT for consideration.

A series of unexpected and unavoidable events during the past few months has led to a delay in publication of the 1975 Proceedings. It is hoped that delays of this nature will not occur in the future and that the Proceedings can be in the hands of the members by June 1 each year.

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PROGRAMS OF ASSCT MEETINGS FOR
1975

PROGRAM OF FIFTH ANNUAL JOINT MEETING
Fort Walton Beach, Florida
June 19-20, 1975

June 19
Morning Session

Registration
Plenary Session

Welcome: Stanley Hooks, President, Florida Division
Welcome: John J. Seip, President, Louisiana Division
Address: The World Sugar Industry - Where It Is and Where It's Going - Dudley Smith
Report: General Secretary-Treasurer - Denver T. Loupe
General Business: Denver T. Loupe

Afternoon Session

Joint Meeting of Agricultural and Manufacturing Sections
Chairman: R. A. Catala

Papers:

A seedcane handling system: Florida - Richard Symes
Development in mechanical planting: Florida - Barney R. Eiland and Joe E. Clayton
Growth, production, and leaf N content of sugarcane in Texas - J. R. Thomas and
G. G. Oerther, Jr.
The effect of fertilizers and soil variability on sugarcane yield and its components -
Laron E. Golden
Predicting delivery rates and economics of transporting sugarcane to the mill -
Billy J. Cochran and Richard W. Whitney
A possible causal organism of ratoon stunting disease - K. E. Damann, Jr.
Ripening effects of glyphosate: Results of experimental permit testing in Louisiana during
1973 and 1974 - K. R. Frost, Jr.
Response of sugarcane to delayed covering and seedpiece size - Dempsey M. Broadhead
Sugarcane technology: Associate of Science degree program at Nicholls State University -
C. J. Falcon and R. N. Falgout
Deterioration losses in Florida sugarcane - Ronald P. DeStefano

June 20
Morning Session

Manufacturing Section
Chairman: B. B. Beyt

Papers:

An automated method for analyzing large numbers of sugarcane juice samples - B. L. Legendre
A raw juice mass flowmeter in a sugar mill - G. Aleman, A. Arvesu, and C. Reynaldos
Effect of biocide on sucrose recovery and microorganism control in cane sugar raw juice -
R. J. Christensen, J. J. Krolczyk, and R. E. Finch

Expected problems of the sugar and related industries in meeting E.P.A. standards -
Wayne Smith

Heavy duty chopper-fiberiser - Unice Machine Co.

The use of package boilers in the sugar industry - P. K. Hall

Electronic steam purity studies insure clean reliable cane mill energy - John Opelha,
G. L. Wheeler, and P. R. Arellano

Experiences during the 1974-75 crop at Cowley Sugar House, RGVSGI Texas - N. J. Saxby,
Jose Martinez, Segundo Valle, Rafael Soler, and Gerry Orillion

Agricultural Section

Chairman: Robert L. Allain

Papers:

Influence of fenac and terbacil on growth and yield of sugarcane - R. W. Millhollon

Factors affecting the expression of juvenile symptoms of the ratoon stunting disease -
J. E. Irvine

The effect of hot water and fungicide treatments on sugarcane seedpiece germination -
H. J. Andreis and E. H. Todd

Short hot-water treatment for the control of the ratoon stunting disease of sugarcane -
G. T. A. Benda

Development of an aerated steam system for the control of ratoon stunting disease -
Billy J. Cochran, Mansel M. Mayeux, and R. J. Steib

The use of aerated steam for the control of ratoon stunting disease in Louisiana -
O. M. Cifuentes, R. J. Steib, Billy J. Cochran, and Mansel M. Mayeux

Some calculated costs and returns from monitoring Florida sugarcane for the sugarcane
borer, Diatraea saccharalis (F.) - T. E. Summers

Parasitism and control of the sugarcane borer by field released Lixophaga diatraeae (T.) -
T. E. Summers

Host resistance to Diatraea saccharalis (F.): Relationship of sugarcane to internode
hardness to larval damage - F. A. Martin, C. A. Richard, and Sess D. Hensley

Modification of pinto bean diet for the sugarcane borer with sugarcane plant parts -
R. D. Jackson

Afternoon Session

Joint Meeting of Agricultural and Manufacturing Sections

Chairman: J. W. Beardsley

Papers:

The comparative efficiency of pre- and post-emergence herbicides not labeled for use in
Louisiana sugarcane - Ernest R. Stamper

Pre- and post-emergence herbicides compared in Florida sugarcane - J. R. Orsenigo

Genetic uniformity among and within varieties: A potential source of vulnerability to
diseases and insects - M. T. Henderson

Studies on synchronization of flowering of sugarcane - Elias D. Paliatseas

The sugarcane selection program at the U. S. Sugar Corporation - D. G. Holder

Sugarcane variety testing in a new area of Louisiana - Hugh P. Fanguy

The genetic behavior of resistance to lodging in sugarcane - Howard P. Viator and M. T. Henderson

Breeding behavior of sucrose content in parents and progeny of eight biparental sugarcane crosses - C. A. Richard and M. T. Henderson

Selection for high sucrose clones from single stool brix data - C. A. Richard and M. T. Henderson

Purity as a selection criterion in sugarcane - P. M. Lyrene, J. D. Miller and N. I. James

Selection for cold tolerance in sugarcane seedlings - R. D. Breaux and J. E. Irvine

PROGRAM OF 1975 ANNUAL MEETING OF THE FLORIDA DIVISION
Clewiston, Florida
October 10, 1975

Registration

Welcome: Stanley Hooks, President

Joint Session of Agricultural and Manufacturing Sections

Chairman: Rafael A. Catala and J. W. Beardsley

Papers:

A functional layout for boiling house equipment, its importance to operation and supervision - Gerardo F. Fundora¹

Vacuum pan performance, Part II - Guillermo Aleman¹

Controlled environmental methods for evaluating cold and freeze tolerance of young cane - Gary J. Gascho¹

Characteristics of sugarcane varieties affecting harvester efficiency - J. E. Clayton, B. R. Eiland, J. D. Miller, P. M. Lyrene, and H. H. Samol

Comparison of cost of various planting systems for sugarcane - L. A. Halsey and E. R. Eiland¹

Effect of delay in covering and seed piece length on germination of spring planted sugarcane - J. D. Miller and B. R. Eiland

Studies of rodent damage and rodent population dynamics in Florida sugarcane - U. S. Wildlife Service¹

Enhancement of flowering in Clewiston (CL) varieties by controlled photoperiod - D. G. Holder¹

PROGRAM OF 1975 ANNUAL MEETING OF LOUISIANA DIVISION
Baton Rouge, Louisiana
February 6-7, 1975

February 6

Registration

Call to Order: Kermit Coulon, President

Technical Session

Chairman: F. Neal Bolton

Papers:

Quality of bagasse as a fuel: Preliminary observations - John J. Seip

¹ Manuscript of this paper was not available for publication in these proceedings.

A new approach to automatic density control - Jim Simpson

Preliminary report on the 1974 factory-scale core studies - Harold S. Birkett

A review of wet scrubbers at Jeanerette Sugar Company - Isby Schexnayder, Jr.

Raw sugar marketing in a changing environment - Benjamin A. Oxnard, Jr.

February 7

Technical Session

Chairman: R. D. Breaux

Papers:

Growth regulators to increase sucrose in sugarcane - Benjamin L. Legendre

A comparison of the Massey Ferguson 102 combine to the conventional harvesting system -
Dan Duplantis, R. Charles Hodson, and Benjamin L. Legendre

Causes of low yield of cane and sugar per acre in Louisiana: Panel discussion -
M. J. Giamalva, Hugh P. Fanguy, H. Koiike, R. W. Millhollon, Eugene Graugnard, and
L. L. Lauden

PAPERS PRESENTED AT FIFTH ANNUAL JOINT MEETING

Fort Walton Beach, Florida

June 19-20, 1975

WELCOMING ADDRESS

John J. Seip, President
Louisiana Division
ASSCT

Representing the Louisiana Division I would like to extend our greetings to the Fifth Annual Joint Meeting of the American Society of Sugar Cane Technologists--and to our guests.

There are many things that we tend to take for granted, and this is certainly true in the case of our technical association. For this reason I would like to make some brief comments on the history of the organization as well as that of the commercial sugarcane operations in the mainland areas represented by our members.

That the mainland sugarcane area should have had a technologists' association is self evident. Why it was so late in coming into being poses a question. As early as the 1890's, the Audubon Sugar School of LSU was a world recognized research and training center. In 1924 in Hawaii, American representatives participated in the formation of the International Society of Sugar Cane Technologists. The occasion was the Pan-Pacific Food Conference. Members of the Sugar Section took this opportunity to organize the International Society and to promulgate the proceedings of the 1st Congress.

An increasing incidence of mosaic culminated in a production of only 47,000 tons of sugar in 1926. The ravages of this disease were anticipated by technologists as early as 1919. This incident alone clearly showed the need for a technologists' organization which could serve as a sounding board to anticipate problems confronting the industry and to suggest possible solutions to the problems.

It is possible that the preparations for the Sixth International Congress of the ISSCT in Louisiana in 1938 provided the necessary catalyst. This Congress was held in the fall of that year.

The Foreward to the first proceedings of the new organization of technologists notes in reference to the formation of the organization in April, 1938:

"At that time, a small group met at Louisiana State University and organized themselves into a band of workers whose efforts were dedicated to the advancement of the Louisiana sugar industry. The members of this group know that through the history of former years, many notable cases of progress can be found which were conceived in the minds of plantation men. While it was their aim and desire to bring into their membership all of the highly trained scientists, they sincerely wished to interest all sugar men in joining in an effort to take advantage, as an industry, of anything that is new and worthwhile for the betterment and advancement of the Louisiana sugar industry."

The name selected for the organization was the Louisiana Sugarcane Technologists Association. Three types of members were recognized, i.e., Active, Associate, and Supporting--and three sections were formed, i.e., Management, Agricultural, and Factory. The officers elected were:

W. G. Taggart	President
W. Daubert	1st Vice President
J. J. Munson	2nd Vice President
Walter Goudchaux, Jr.	Secretary-Treasurer
H. C. Pitcher	Chairman, Management Section
George Arceneaux	Chairman, Agricultural Section
M. V. Yarbrough	Chairman, Manufacturing Section

The first organizational meeting of record was August 30, 1938, and--as a matter of interest--the second paper was titled "Condition of Cane Entering the Factory" by Arthur Keller. This reference to cane quality in the days of hand harvested cane bears out the observation of the preacher in Ecclesiastes that "there's nothing new under the sun." The early meeting format included separate sectional and general meetings. This was subsequently formalized into biannual meetings in February and June.

In 1945, in recognition of the increasing membership from other states--and the national scope of the aims of the organization--the name was changed to the American Society of Sugar Cane Technologists.

The reorganization of the Association to include the Louisiana and Florida Divisions is current knowledge. On February 5, 1970, the Constitution was ammended to recognize the two divisions, five instead of three classes of members, and two sections, i.e., Agricultural and Manufacturing. The first joint meeting was held in June, 1971, in Pensacola, Florida.

The Technologists' Association represents three wholly separate mainland cane growing areas and it might be interesting to attempt to also set the record straight on the history of the industry in these areas.

The claim to the first commercial-scale production of sugarcane and sugar may have to be conceded to Florida with the New Smyrna Colony operations in 1767 to 1776 on the west coast. Commercial-scale operations were also associated with Manatee County in 1850-1860, St. Cloud in 1888 to 1896. The Pennsylvania Sugar Company operations in Hialeah, and the Canal Point factory, both of short duration, were initiated in 1924 and 1923.

Current history begins with the Dahlberg years (as they have sometimes been called) from 1930-35 with the consolidation of existing equipment from Hialeah and Canal Point--and new equipment--into the 1500 tpd Southern Sugar Company factory at Clewiston in 1928. Brohr G. Dahlberg was president of the Celotex Corporation, based in Chicago, and set for his goal making Clewiston one of the leading industrial centers in Florida--and the factory one of the largest on the mainland. The factory was expanded to 4,000 tpd in 1930. A series of adverse circumstances forced the company into bankruptcy, which culminated in the purchase of the assets by the U. S. Sugar Company in 1931. The rest is history, a highly successful venture by U. S. Sugars, an active and aggressive varietal breeding program by U. S. Sugars and the USDA Canal Point Station, (which was initiated in 1920), and an expanded sugar industry.

Texas had its sugar bowl in the five county area in the vicinity of Sugar Land, the first of 35 mills being constructed in 1843. Subsequent records refer solely to the continued operation of the factory at Sugar Land, with the addition of its own and offshore sugar refining facilities in 1902, a change in name to the Imperial Sugar Company in 1906, and the subsequent dismantling of the raw factory in 1928. The site is that of the current Imperial Sugar Refinery.

The first sugar factory in the Lower Rio Grande Valley was built in 1858. The industry in this area reached its peak in 1913 with five factories, and subsequently declined. This period of history came to an end with the removal of the San Benito mill to Hialeah in Florida.

Here, too, a new era began with the operation of the new W. R. Cowley Sugar Factory in 1973.

We in Louisiana may not be able to claim the first or the largest commercial-scale sugarcane ventures. We can claim the continuingest. Successful commercial-scale operations are generally credited to Etienne de Bore' in 1795 on the site of the Audubon Park in New Orleans. De Bore's place in history is associated with his successful efforts to granulate sugar in a form suitable for export.

We forget that early failures in the industry were generally associated with the quality of the commodity, which was a gummy mass of crystals and molasses which leaked through the hogsheads or barrels onto the wharfs and the ships. De Bore's efforts led to a marketable commodity, and the Louisiana export trade subsequently flourished.

The industry expanded and prospered in the golden pre-Civil War era. Records show 865 steam driven factories during the 1849-50 crop--and a peak production of 264,000 tons of sugar in 1861. This record was not exceeded until 30 years later in 1893.

As a further item of contrast, it is interesting to note that in 1938, when the Association was formed, the mainland sugar production was 584,000 tons. The corresponding figure for the current 1974-75 crop--reflecting production in Florida, Louisiana, and Texas--was 1,464,000 tons.

My predecessor as President of the Louisiana Division, Kermit Coulin, in his final address at the February meeting (with tongue in cheek) equated his tenure in office with the spectacular rise in sugar price during the 1974-75 crop. In teaching statistics at LSU, we advise caution in correlating unrelated events such as the incidence of smoking among pregnant women in Sweden with the birth rate in the U. S. I will use the same care in equating the increase in raw sugar production with the activities of the American Society of Sugar Cane Technologists. However, I would like to feel that the activities of our organization, representing all segments of the industry, have been a factor.

I thank you for the privilege of addressing you and wish for all the thoroughly enjoyable social activities which have become a hallmark of our annual meetings--and additionally the benefits to the mainland industry of a fruitful and informative technical program.

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THE WORLD SUGAR INDUSTRY
WHERE IT IS AND WHERE IT'S GOING

Dudley Smith

Before

The production and marketing of sugar clearly has emerged from a 40-year epoch and give every evidence of embarking on a completely new period in sugar history. It seems highly probable that we are now facing a new revolution in sugar, such as that which happened in the mid-1930's to start the period which we have just completed. The review of certain developments in sugar demand and production in this period just past, in the light of trends now in progress, will assist in evaluating what is likely to happen in sugar in the years ahead.

The United States sugar industry, probably as much as that of any other division of the world industry, must look forward in a completely changed situation from that in which it has operated in the past. The position of the industry today, without a sugar law and with only a nominal tariff rate on imported sugar, must look forward to conditions distinctly from that of the 1920's and early 1930's, when the tariff amounted to a large percentage of the domestic price, and from that starting in 1934 when a quota system regulated the entry of sugar into the U.S. market. In addition to changes in the market structure, this country is the outlet for a very smaller percentage of the world production than it was in the 1920's and 1930's.

One of your main interests in the future is the kind of market in which you will be selling your sugar. With world trends now in progress and without the U.S. Sugar Act, the market will be largely tailored by what happens in the rest of the world, certainly to a greater degree than that which most of us have known in the past.

Sugar markets are tailored mainly by the demand or consumption of sugar, on the one hand, and the quantity available to meet the demand. There are many ramifications of this simply stated principle, including who buys it for consumption and where and under what conditions it is produced. With market limitations, this country could restrict the impact of world-wide conditions, but now, the world market will be an important factor in determining the conditions under which U.S. sugar will be sold.

The West Indies and Java were the main sources of centrifugal sugar until the latter 1800's, with Europe and the United States being the major buyers. Most of the rest of the world consumed locally produced, non-centrifugal sugar. At the beginning of the 20th Century, world sugar production was comprised of about 8.5 million metric tons of centrifugal sugar and about double that quantity of the non-centrifugal product.

Development of sugar production and consumption from the early 1900's to the early 1930's provides an interesting contrast with conditions today and the availability of capital for future expansion. In that period, three countries were important in the expansion of centrifugal sugar production; these were the Dutch in Java, the British, mostly in the West Indies, and the United States in the West Indies, Hawaii and the Philippines. Over expansion in the latter 1920's, especially in the areas financed mostly by the United States, led to serious problems in marketing and gave rise to the first round of protective measures. These measures included Tariff increases in many of the importing countries and later such restrictive measures as the Chadbourne Agreement, the U.S. Sugar Act, the British Commonwealth Agreement, and the International Sugar Agreement.

These various protective measures show strong evidence of having just about run their courses and the sugar markets of the world are wide open again.

One of the striking developments in sugar markets since the mid-1930's has been the decline in the percentage of the world output of centrifugal sugar which has moved at the unprotected or world price. This was part of a development in which the consumption of sugar in the United States and Europe, the main importers prior to the 1930's, failed to rise like consumption did in the rest of the world. This latter was the effect of the much, much more rapid rise in sugar consumption, percentage wise, in countries that consumed little before. This was made possible by expanded production of sugar in these same countries.

It is these changes in world sugar consumption and production from 1934 to 1974, and the bases of these changes, that are highly indicative of what is in store in sugar markets in the years ahead.

Looking at market changes, world sugar consumption was about 25 million metric tons in the mid-1930's, of which the United States used 6.0 million metric tons, or about 25 percent of the total. Europe and the U.S.S.R. used about 13.5 million tons, or 45% of the world total. All of the rest of the world, accounted for about 11 million metric tons or about 30% of all centrifugal sugar consumed at that time. Now, the United States is up to about 10.5 million metric tons, or about 13% of a much larger world total, which means that we now consume only one-half as large a share of the world sugar consumption as we did 40 years ago. Europe and the U.S.S.R. also have lost their percentage of the total, now standing at about 39%. But the rest of the world has soared from about 11 to about 39 million metric tons, or about 48 percent of the total use of centrifugal sugar.

In all parts of the world, sugar consumption has risen in two ways; (1) more people to eat sugar (and undoubtedly a still greater increase in the people actually eating the product), and (2) a significant rise in the percapita intake, whatever the cause, in many countries. It is these changes of the past that are strongly indicative of what will happen in the future.

Over the years, there has been a strong tendency for the human intake of sweets to rise to about 50 kg -- 110 lb -- percapita, with the intake leveling off as that rate is approached. This has been an important factor in the tendency for total consumption to level off in the United States and some of the countries of Europe. It will be an important factor in other countries in the years ahead. There are still many countries where percapita consumption levels are low and it has been the rise from these low levels that has been an important factor in the rapid increase in sugar intake in the rest of the world, since many of the so-called "developing" countries still have the potential for wide rises in sugar consumption, if they are able to obtain the sugar.

The other major factor in the rise in sugar consumption in Asia, Latin America and Africa has been population explosions. In the mid-1930's, the world had about 2.2 billion people, up from 1.6 billion in 1900. Currently, the world population is more than 4.0 billion and in many countries still rising very rapidly. The rise in number of people in the world from 1934 to 1974 was about 82%. In that period, world percapita sugar consumption rose from about 11.5 to about 20 kg., a rise of about 74%. Thus, it was the combination of these two factors that lifted the total consumption of centrifugal sugar by 220 percent.

Where these changes in population and percapita sugar intakes occurred, trends currently in progress in the many parts of the world, and the judgment of the experts on future trends that show where the U.S. sugar market will stand in the world total in the future.

To look at the trends of the United States, the population rose from the proximity of about 130 million in the 1930's to about 210 million now; less than 250 million people are indicated for 1985 and only a little more than 275 million for 1995, according to U.N. population experts. With the consumption of caloric sweets stabilized at about 50 kg, the U.S. market will need about 12.5 million metric tons (about 13.8 million short tons) at the end of the next ten years and probably 14 million metric tons by the end of 20 years. You may hear higher figures, but that is the arithmetic.

The population of North America, Europe and the U.S.S.R. is estimated to rise by about 100 million in the next 10 years and by probably as much as 200 million in the next 20. In contrast with the population growth in the developed world, that for Latin America is estimated to be in for an increase of 110 million, or 35 percent in ten years and 232 million or 75 percent in twenty years. Similarly, the number of people in Asia is estimated by the U.N. population experts to rise by approximately 580 million in ten years and 1.22 billion in twenty years, or 25 and 53% respectively. And the population of Africa is estimated to go up by 133 and 283 million people in these two periods, or by 33 and 71% in ten and twenty years.

The combined percapita consumption of sugar in North America, Europe and the U.S.S.R., viewed in the light of past trends, is not likely to rise more than 5% in the next 20 years, when it still will be less than 47 kg. On the other hand, the individual level of consumption among people in the so-called developing countries will go up about 30 percent in this period, or from approximately 12.3 kg in 1975 to probably as much as 30 kg in 1995.

These data regarding population and percapita sugar consumption, which at best are only approximations but still the best indications we have of future market demand for sugar, indicate that by the end of the next 20 years, about 80 to 82% of the annual increase in the demand for sugar throughout the world will be in the so-called developing nations.

These computations of future sugar demand in parts of the world other than North America, Europe and the U.S.S.R. should be qualified, in my judgment, by the probability that in the future the developed countries of the world will be unwilling to undertake the feeding of run-away populations and that the poor countries, with their lack of education and modern technology, will be unable to supply such quantities of sugar to their booming populations. In this case, the effects of hunger may prevent population in the under-developed countries from reaching the levels projected on the basis of current trends.

The realistic appraisal of population trends and percapita sugar consumption levels does not make it appear that the world demand for sweets will reach much more than 100 million metric tons by the end of ten years and not significantly above 125 million tons within the next 20 years. Nevertheless, certain projections have indicated considerably higher figures within these periods.

All of this may, in the final analysis, not matter too much to you as American sugar producers. The current trends indicate that demand for sugar will not expand to much in the United States and other parts of the industrialized world. The strong expansion in sugar will be in areas that have not, in the past, been important buyers of sugar in international markets. Of equal importance to the developed world is the fact that these countries, by all indications, will be obtaining the major part of their sugar from sources not heretofore important as sugar producing areas.

There are other factors that are likely to be more important to you as the producers of sugar in the world's most industrialized nation. We have been concerned, from time to time in the United States, about the replacement of sugar by substitute sweeteners. We have had many threats, but today dextrose is the only substitute sweetener that has taken a significant part of the sugar market, and most of that in this country.

There is today another product which clearly represents a much more serious threat in the highly industrialized countries. This is the development which looms as a threat to the U.S. sugar producers, and especially to the beet industry.

Japanese scientists, a few years ago, devised an enzymic process of producing from starch isomers which are the mirror twins of dextrose and levulose. This product has come to be called isomerase in the United States. These isomers are an almost exact duplication of invert sugar produced by the inversion of sucrose. By all indications, these starch-based sugars will replace, within a few years, much of the sugar now delivered to industrial users in liquid form. A realistic appraisal of this market indicates that within the next decade, as much as three million tons of sucrose may be replaced in this way. It may even develop that other phases of the U.S. market for sugar will be filled with this product.

Certain other countries also are looking over this new sweetener, especially Japan. While the starch, used as a base for the new product, will be made from corn in the United States, it will be made from sweet potatoes in Japan. And if current sweetener studies in Europe bring the use of sweetener, the starch will be made mainly from white potatoes.

It is only in the United States that developments already have reached proportions which threaten the replacement of large quantities of sugar. Several corn wet milling companies are modifying processes and expanding facilities for the manufacture of starch isomers. Some of the cane sugar refiners and at least one beet sugar manufacturer, either on their own or in combination with others already in the corn milling operation, started construction of plants for the manufacture of isomers of starch. Most of these facilities will be in or near the corn and grain sorghum producing areas of the mid-west and Texas. This also places them near the intensive sections of food manufacture and the major livestock feeding regions.

American sugar producers may face the future with shrinking markets for their product. Almost from the beginning of production, they have had an expanding outlet, generally being able to sell more sugar each year than in the one before. By selling in a stable, if not declining market for sucrose, new problems will likely be faced.

With world sugar developments in both demand and production largely bypassing the United States, and with the indicated replacement of sucrose with starch-based sweeteners, future prospects for the sale of U.S.-produced sugar may appear bleak at first. However, the U.S. sugar producers are no longer tied to a fixed percentage of their own market. For the first time in 40 years they can increase their sales without having to go to the Congress for authority to supply more of their own market. The ratio between U.S. and foreign sugar in the U.S. market became "unfrozen" with the expiration of the Sugar Act.

Sugar is produced with a much higher level of proficiency in the United States than anywhere else in the world, except for Australia. This is especially true of the agricultural phases. Moreover, the Sugar Act had become top-heavy with bureaucratic regulations and favoritism to foreign producers. Thus, it seems to have been an appropriate time to permit the Act to expire.

The closeness with which sugar consumption and production have developed together in the same countries and in the same approximate magnitude over the past 40 years indicates that this will continue to be the pattern for the future. Although the focus is frequently on the so-called world market, the real development in sugar production has been to supply consumption needs in the consuming country. The amount of sugar selling in the unprotected market has not increased in line with the rise in the total production throughout the world, which reflects the tendency for the product to be consumed where it is made.

This same development is indicated for the future. Two important cases in point are the countries of West Africa trying to establish production to supply the growing demand of their population for sweets, and the Middle East where international agricultural and financing agencies are planning studies for programs to make the region more or less self-sufficient in sugar.

If the United States sugar industry goes forward without any protective device such as the Sugar Act -- and the time may have passed when this Act can be put back in operation -- we face a completely new era in sugar production and marketing. The important questions for the intermediate future for American producers relate to the conditions under which sugar will be produced and marketed. How can such producers be competitive with foreign areas where daily wages often are less than the hourly wage in sugar fields in this country? At what levels can the price of sugar be maintained in the U.S. market in the absence of quantitative limitations? What factors surrounding production in many of the foreign producing areas may have an impact on their costs which will keep U.S. producers competitive, notwithstanding high wage and cost structures?

The statutory tariff on sugar from the full-duty countries continues to be 2.5 cents a pound, even though the effective rate is less than one cent. If, in the absence of quotas, returning the tariff to the full rate would provide only limited assistance to the industry. In the early 1930's, this tariff was equal to round 80 percent of the raw sugar price within the United States. Today, it would be only about 15 percent of such price.

This presentation does not presuppose that no change will be made in the conditions of entry of foreign sugar into the U.S. market, or that U.S. producers will have to sell their sugar at prices resulting from the dumping of the small portion of the world output which must be sold without protection. Instead, it is an effort to look at the positive as well as the negative factors the United States enjoys in this new phase of sugar marketing. In this regard, attention will be given especially to those conditions which affect costs and place sellers in favorable or unfavorable marketing positions.

As technologists, we tend to think of favorable conditions for sugar production in terms of local matters, particularly climate, soil, moisture, drainage and related things. The U.S. sugar areas have these conditions on a parity with the rest of the world. There are many other things, however, that have a profound effect on costs and other aspects of sugar marketing; many of these are man-made and are largely beyond the control of sugarcane growers.

Since you, as technologist, are deeply committed to cane sugar, you want to be informed on many of the things which have an important bearing on the ability of the American sugar industry to be profitably competitive under the new situations in which we find ourselves.

Probably the first advantage enjoyed by the American industry is that this nation has a significant deficit of sugar, with the result that large quantities must be imported. This gives the U.S. producers the advantage of being inside of the market instead of having to ship their sugar hundreds, or even thousands, of miles to market. The location within the market offers both savings in marketing costs and advantages in the actual sale and delivery of the sugar. In relation to some of the foreign suppliers, this advantage may approach 100 points in the net position.

The point on which the American sugarcane growers have the greatest advantage is in the matter of science, technology and mechanization and the effect these developments have on the cost of producing and marketing sugar. Few, if any, other agricultural enterprises depend as heavily upon these as do sugarcane growers. Hawaii, Florida and Louisiana each has a mass of information and technology developed through research which is unequalled elsewhere, except in the case of Australia. Moreover, the individual sugarcane grower has a level of education achievement equaled in few, if any, other areas, and this is basic to the assimilation and utilization of the mass store of technical information developed by the scientists engaged in research.

The advantage, in economic terms, of the availability and utilization of the mass of technical and mechanical information by sugarcane growers is reflected in the tons of sugar produced per acre per month, or per man hour of agricultural work. The high levels of productivity are directly reflected in cost and give American sugarcane growers a basic advantage in supplying sugar to the market at competitive levels. This can best be illustrated by the pounds of sugar produced per man hour of agricultural work, with the U.S. areas having an average of about 125 pounds. Only Australia, in the rest of the world, equals this rate, with many countries falling in the range of 25 to 40 pounds of sugar per man hour, but with many areas falling below 15 pounds.

This productivity gives a great advantage in production costs, although it must be recognized that much higher wage rates in the American areas and the cost of sugarcane machinery and its operation are offsetting factors.

Another condition having a great impact on the proficiency of sugarcane production is the tendency for Governments to meddle in the affairs of sugar industries to a much greater extent than they do in those of any other industry, especially in agriculture. The U.S. industry has recently been freed from many of the unnecessary Government regulations with the expiration of the Sugar Act. There remains, nevertheless, a large mass of Government regulation and "meddling" with which sugar people must deal, although these have general application and are not peculiar to sugar. Such things as EPA, OSHA and many other agency regulation take a large part of the time of managerial and technical personnel in sugar companies and create a significant amount of hidden costs which must be reflected in the cost of the sugar. To the extent the U.S. sugar people must concern themselves with such matters, their ability to meet foreign competition is reduced.

This tendency for Governments to meddle in the affairs of sugar industries is much more capricious in other countries than in the United States. Throughout the world, sugar is frequently singled out for one or more kinds of prejudicial public action. Too often, the industry is saddled with a disproportionately large share of the country's social problems. In many cases, the price of sugar in the national market is controlled at very uneconomic levels, frequently for political motives. Taxes on sugar industries, imposed in one way or another, are often out of proportion to those imposed on other industries. Encroachment of Government ownership and control of the industry in many countries is creating unfavorable background conditions and making producers in many areas non-competitive. It might be observed that in most countries where public ownership is characteristic, cost tend to run much higher than they do in countries where this is not the case.

The frequency, from country to country, in which sugar has been picked out for a variety of Government exercises is striking. This seems to have no geographic limitations and may be done indiscriminately in large or small countries. Many countries could be mentioned in which public action on sugar is crippling the industry, some to the extent of falling seriously behind economically.

On the other hand, there are a number of countries in which the owners and operators of sugar property have been unmolested and have been left free to carry on effective operations. Ethiopia, until recently at least, has made it possible for sugar operations to be carried on in an effective manner with a minimum of Government interference. There are even a number of countries in which the Governments have taken positive and well informed actions to promote the sugar industry and raise the proficiency of operations. In countries like Brazil, Swaziland, Thailand and the Philippines, sugar production has been enhanced and improved under Government sponsorship and assistance.

While increased costs resulting from capricious and unwise Government action will limit the competition U.S. sugar producers will encounter in their own market, enough countries continue to be relatively free from such problems to supply enough sugar to the American market to keep prices on the restricted side.

Sugar production in a large and growing list of countries is impeded by public policies on land ownership and operation, a factor which has not been bothersome to sugar operations in many parts of the United States and not at all in the sugarcane producing areas. In many parts of the world, this limitation on land is popularly termed "land reform" and Government regulation limits the ownership and control so one person may hold only relatively small parcels of land. While this idea is not new to land tenure, it has had an upsurge in recent years due in part, at least, to the programs of foreign aid agencies, including those of the United States;

It has been highly interesting to observe critically from country to country the impact of farm size on the managerial and operational proficiency of sugarcane production. Efforts to grow sugarcane on literally millions of very small farms impose very low technical levels on sugar

production and essentially eliminate the opportunity for increased productivity through the use of modern mechanical equipment. In efforts to circumvent the effects of mini-fundia, extensive and costly steps are taken in some countries to group small land parcels to make operating units of sufficient size to support acceptable operations. Nowhere has it been possible to establish and maintain technical, scientific and mechanical proficiency and bring sugar production to an economic and competitive basis to the small, individually operated farm structure.

Notwithstanding the extremely low man-hour and per-acre production always characteristic of the miniture farm operation, foreign aid officials from both the U.N. and the U.S. continue to promote land reform in the developing countries. Cane sugar production in many of the countries newly entering the business is being tried on the basis of small farm operations. This completely overlooks the fact that the farmer who knows no plow but a sharp stick and no hammer but a stone cannot bring or maintain modern methods to the land he tills.

Another factor in the sugar outlook for the intermediate future -- one not connected with public policy -- is the relationship of the cost of new plantation-factory complexes to the general concept of the price for the sugar that will be produced. This has been an important factor in the fact that factories now under construction or under contract and which will be initiating operations in the next five years, when they reach full capacity, will still provide a quantity of sugar equal to about one year's increase in world demand. Unless sugar prices remain at or about the current levels for a number of months, this concept of the prices to be obtained for the sugar from new installations will have the effect of additionally restricting or delaying expansion.

The important point in the consideration of the intermediate future of the Louisiana and Florida sugar industries, I feel, is that few, if any, of the countries so heavily burdened by limitations on land holdings and bureaucratic limitations are likely to be important factors selling sugar at open prices in the U.S. sugar market. On the other hand, impediments to the rapid and extensive expansion of production facilities will leave a demand and market for increasing quantities of sugar in countries that do not supply all of their own needs which will take off much of the output of those countries, such as Brazil, that are not hampered by such restrictions and regulations.

In brief summary, at this stage, the situation is not wide open, but world demand for sugar seems to continue to exceed production to an extent that prices are likely to continue stabilized and that the market show little evidence of becoming demoralized as it constantly threatened up to a couple years ago. This situation may be expected to give the U.S. sugar industry time to adjust to new conditions in the market which will result from the absence of quantitative restrictions on the entry of foreign sugar into the United States market.

A SEED CANE HANDLING SYSTEM

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ABSTRACT

The necessity to plant considerable acreage of cane in a short period of time prior to seed loss from cold introduces a review of traditional planting systems in Florida. The difficulty in reaching high rates of planting due to the inability to provide seed to the planting crews from seed fields many miles away led to attempts to use dump trucks. A discussion of the adaptations made to the dump trucks, and the methods of loading and unloading is given. A review of the advantages and disadvantages is made. An off-season use of the newly developed equipment is suggested.

DEVELOPMENTS IN MECHANICAL SUGARCANE PLANTING IN FLORIDA

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ABSTRACT

Approximately 75,000 acres of sugarcane are planted each year in Florida. The planting of sugarcane begins in August and continues until April if severe freeze damage does not occur. The total number of acres planted each year is primarily dependent upon the availability of labor and the weather. There are several different methods for planting sugarcane, but most utilize hand labor for cutting the seed material and hand labor for planting the seed material. There are two mechanical planters used in Florida -- the Glades County Sugar Growers Cooperative Association planter and the Sugar Cane Growers Cooperative of Florida planter. Several planters have been tried or developed for Florida that were not successful. Currently, there are several planters under development by different organizations. The success of mechanical planting is dependent upon the seed length, the trash content of the seed material and variety characteristics.

INTRODUCTION

Florida's sugarcane producers face an enormous array of problems when sugarcane planting begins in August of each year. These problems relate to weather, equipment, labor and the logistics of planting. Each year approximately 75,000 acres must be tilled, furrowed, planted and covered. The most labor intensive parts of the planting operation are the dropping of the seed material into the furrows and the cutting of the seed material for planting.

The total number of acres planted is dependent upon the weather, producers' rotation requirements, the length of the planting season before freeze damage occurs and the availability of labor. These factors cannot be readily controlled by sugarcane producers. Since a ready availability of labor generally indicated high unemployment, imported labor and other alien labor cannot be depended upon for the difficult tasks. These possibilities, along with possible economic savings, have created an interest in planting mechanization.

In the 1973-74 season, approximately 63,100 acres were planted by hand, and no planting was done mechanically. During the 1974-75 season, 90,000 acres were planted by hand, and 2,500 acres were planted mechanically primarily by Glades County Sugar Growers Cooperative (data obtained via personal communication). (Trade names are used in this publication solely to provide specific information. Mention of a trade name does not constitute a warranty or an endorsement of the product by the U.S. Department of Agriculture to the exclusion of other products not mentioned.) With improved planters and new crop management techniques, more sugarcane producers will probably begin mechanical planting.

MECHANICAL PLANTING DEVELOPMENTS IN FLORIDA

Early mechanical planting attempts in Florida resulted in the development of planting aid wagons (3,7). In the last 5 years, several different mechanical planters have been tried in Florida. A USDA planter with horizontal metering buckets was tested (2). A three-row unit that would accept seed material from the rear of a planting aid wagon was constructed. Several modifications were made in which different bucket sizes and speeds were used but none was very successful.

In March 1973, an Australian type planter (6) was demonstrated at a Field Day. The seed material was distributed from the hopper by hand, and final metering was by a horizontal bucket conveyor. The row was furrowed and the seed pieces were covered by the planter in a single operation. This unit is not currently used in Florida due to its requirements of clean and uniform length seed material.

A mechanical planter was designed in 1973 by Ray Hatton, a sugarcane producer from Pahokee, Florida. It was a one-row unit designed to plant seed material without an operator's observation. The unit had a conveyor in the wagon floor that continuously fed a slat conveyor that deposited the seed material in the furrow. The unit was dismantled after initial field trials in 1973.

In late 1973, Noble Rizer of Glades County Sugar Growers Cooperative Association, developed an experimental, two-row mechanical planter that operated with the wheels in the furrows. It had a lugged chain that ran the length of the planter and delivered seed material into the

furrows behind the wheels. Stewart Boots, an engineer from Belle Glade, Florida, improved the unit by adding an oscillating inverted-V center in the wagon to aid in seed material alignment (1). The Glades County Sugar Growers Cooperative Association had 10 improved units built for the 1974-75 planting season. They were used to plant 2,362 acres (personal communication with Glades County Sugar Growers Cooperative Association).

During 1974, Larry Fowler of Sugar Cane Growers Cooperative of Florida, developed a mechanical planter (4). The unit plants two rows from the front of the planter. The wheels of the planter are positioned on top of the beds while the outside furrows are planted. The center furrow, located between the wheels, is planted on a subsequent pass. A conveyor in the bottom of the planter moves material forward where it is delivered upward to each side by a slat conveyor. The seed material falls downward and is discharged by a conveyor into the furrow. This unit planted 150 acres in the 1974-75 season (personal communication with Sugar Cane Growers Cooperative of Florida).

Several other mechanical planters are under development by different researchers. Engineers at Okeelanta Sugar Division of Gulf & Western Food Products Company constructed a mechanical planter similar to that developed by Larry Fowler of Sugar Cane Growers Cooperative of Florida. USDA agricultural engineers reviewed seven different possible metering systems for mechanical planting. The general conclusions reached indicated that a lugged chain or slat conveyor with positioning aids would be required for the initial breakup of the seed material. The delivery of this system should feed upward above the reservoir of seed material to allow the discharge of pieces of uprooted stubble and allow excess seed material to slide back. The discharged material should be metered by a vibrating chute or lugged chain to distribute the seed material satisfactorily. A one-row unit that incorporated these features was developed. Engineers at the United States Sugar Corporation are developing a two-row planter that incorporates a slat conveyor that feeds upward from the rear of the planter. The unit delivers the seed-pieces into a vibrating chute arrangement for placement into the furrow. The wheels of the planter are positioned on top of the beds while the outside furrows are planted.

PROBLEMS WITH MECHANICAL PLANTERS

With the number of researchers that are working on mechanical planters, significant progress will probably be made. However, mechanical planting has some serious problems that must be overcome. These are poor stands from short seed material, the influences of variety on planter metering ability, and higher application rates than in hand planting.

The performance of a mechanical planter can be improved by limiting the length of the seed material planted to about 10-12 inches. Short seed-pieces allow better trash removal by mechanical harvesters. A lower trash content in the seed material allows for an easier breakup of the seed material for metering purposes. However, a preliminary field study of the germination of mechanically harvested seed material indicated that germination is reduced substantially when the seed-piece lengths are under 17 inches (personal unpublished data). The germination rate appears to increase linearly with the increase from 6 to 22 inches in seed-piece length. The seed material should be covered immediately because the study indicated that the germination rate decreases with an increasing interval between planting and covering. These preliminary results are from a field experiment in which CP 63-588 was planted in February 1975.

Mechanical planters operate effectively with clean, straight seed-pieces cut to a uniform length. Seed cane grown for mechanical planting should be erect and self-stripping. These characteristics aid in mechanical harvesting and mechanical planting and should be considered in variety selection. Some varieties that do not plant satisfactorily are CP 62-374, CP 63-306 and Cl 54-378. Varieties that can be planted with moderate difficulty are CP 63-588 and CP 56-59.

To prevent significant skips mechanical planters typically apply 1 to 2 tons more seed material per acre than in hand planting. The additional seed material used in mechanical planting is partially justified as compensation for the increased number of damaged eyes resulting from the harvester and planter mechanisms.

A preliminary study by Edwin R. Rice, research agronomist with ARS, USDA, Canal Point, Florida, indicated one continuous line of hand-planted cane produced higher yields than did three continuous lines of cane when averaged over three crops (personal communication). In a later study, when he used one, two and three continuous lines of hand-planted cane, no difference was found in yield averaged over three crops. Seed material planted in excess of the amount required for a good stand of cane is wasted. It is reported that some growers are using as much as 7 to 8 tons of seed material per acre.

CONSIDERATIONS FOR MECHANICAL PLANTING

In preparing for mechanical planting, sugarcane producers should consider certain factors with the previously discussed problems in mind. Soil type will certainly affect the selection of planter wheel location in the field. If soft or a peaty muck soil that will not support the planter on top of the beds is encountered, the wheels must be operated in the furrows. If the planter is operated on top of the beds, it should be attached to the crawler tractor to prevent it from meandering on top of the beds and closing up the opened furrows. Unnecessary trips along the beds will compact the soil and reduce the planting depth of the seed material.

For typical Florida fields, the two-row planter is the largest feasible size if the hopper is refilled at only one end of the field. A planter hopper size of 180-200 ft³ is required for each one-half-mile row planted with typical 20-inch-long seed material. Seed material density decreases with increases in seed-piece length. If the hopper is to be filled at each end of the field, a three-row unit can be used. However, a one-row unit with sufficient hopper size may be satisfactory if the hopper can be refilled only once each hour. This schedule would allow extra time for transport travel between the field and seed material source.

Mechanical planters can plant 8 to 10 acres per day per row unit if they are supplied with seed material in the field. The planters are too bulky for transport to the source of the seed material. A typical single-row chopper harvester harvests a ton of seed material every 5 minutes. Thus, a single-row harvester could supply enough seed material to plant 20 acres per day. An optimum system would probably include the harvester, two 5-ton, high-lift type transports, and a two-row mechanical planter. This system would probably have the transports traveling between the harvester and the planter about 30 to 50% of the time. Seed material could be located up to 4 miles away. With this system 1,000 acres per season should be planted easily in a 90-day planting season.

The different chopping systems in harvesters provide varying qualities of cut and uniformity of seed-piece length. Seed material should be chopped without crushing or splitting the seed material. If the seed-pieces split, their length should be increased to assure satisfactory germination. A minimum length of 17 inches may be sufficient for good germination; however, good cutting action would be required to maintain this seed-piece length. Poor cutting action by a harvester may increase this minimum length to 25 inches. This extra length becomes difficult to meter effectively, because longer lengths inhibit trash removal by the harvester. Trashy seed material retards breakup of the seed material for metering by the planter. A larger planter hopper is required for the longer seed material than for shorter seed material because of decreased density. The longer seed material has a density of 10-12 pounds/ft³ whereas the shorter seed material has a density of 18-20 pounds/ft³. The seed material should be clean, straight, uniform in length, and free of uprooted stubble. Uprooted stubble tends to choke the metering systems of mechanical planters. Continuous loaders pick up the stubble, as do mechanical harvesters.

The season of the year can influence germination characteristics of sugarcane. When young seed material is planted in early fall, a single line of cane is sufficient. In November and December, heavier applications and longer seed-pieces may be required, because germination is related to soil temperature (5). If short seed material or immature cane is used in the fall or winter and freezing occurs, the cane may not recover. In the spring, germination can be reduced by eye damage caused by birds or disease and dormant eyes. These possibilities influence the application rate of seed material and, thus, the selection of planter size and capacity.

DISCUSSION

When using mechanical planters, one must consider the different factors necessary for a good stand of cane. Many factors influence the germination characteristics of sugarcane. These include soil temperature, age of seed material, disease, seed length, and the interval between planting and covering. These factors must be considered to determine the appropriate application rates and cultural methods for mechanical planting. By selecting varieties adaptable to mechanical planting and harvesting, satisfactory stands can be obtained with a minimum labor requirement.

Any new technology presents both advantages and limitations; mechanical planters are no exception. Certain changes in cultural methods, scheduling, and crop management may be required to overcome some of the disadvantages. Ultimately, the sugarcane producer must develop a logical system for mechanical planting based upon research results tempered with field experience.

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GROWTH, PRODUCTION, AND LEAF N CONTENT OF SUGARCANE IN TEXAS

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ABSTRACT

A nitrogen-fertilizer field experiment was conducted from 1972 to 1974 to determine the leaf N sufficiency level for sugarcane in the Lower Rio Grande Valley of Texas. Nitrogen, as NH_4NO_3 , was applied at rates of 0, 50, 100, 150, and 200 lb/acre to sugarcane variety NCo 310. Leaves and sheaths numbered 3 through 6 were collected, and growth was measured periodically throughout each year. The sugarcane was irrigated when 60% of the available water in the upper 3 ft of the soil profile had been used. Daily growth rates were affected more by soil water availability than by N fertilizer rates. However, seasonal mean growth rates were significantly affected by N fertilizations. A 1 in/wk increase in the mean growth rate during the growth period (May through August) increased the estimated yield by 11.5 ton/acre. Sugarcane yields were significantly related to the N concentration of leaves in early June. The N sufficiency level decreased from 2.3 to 1.5% during the growth period. High rates of N decreased the rendement values. Yields of sugarcane were optimum for the 100 lb N/acre application.

INTRODUCTION

Commercial production of sugarcane in the Lower Rio Grande Valley (LRGV) of Texas began anew with the 1972 planting of approximately 25,700 acre (1,8). Growth of sugarcane on soils of the LRGV is limited more by nitrogen (N) and iron than any other plant nutrient. Iron deficiency is readily detected and easily corrected (10). However, since the soils are inherently fertile, management of the N supply to produce optimum growth in cane crops and to maximize sugar yields is extremely difficult. Excessive use of N fertilizer on the commercial cane fields in the LRGV has caused difficulties in burning leaves from the cane and contributed to low rendement (ratio of sugar to cane yields) values.

Foliar N analysis is used in other sugarcane growing areas to monitor the N status of the crop throughout the season (2,4), to establish the basic N-fertilizer rate, and to determine the need for supplementary fertilizer applications. However, as the leaf N content changes with cane age (7) and is influenced by plant moisture content (6), temperature (7), leaves selected for analyses (3), and possibly varieties (5), critical N levels established for other areas may not apply to sugarcane grown in the LRGV.

The experiment was conducted to (a) study effects of N fertilizer on the rate of stalk elongation, leaf sheath moisture, and leaf N concentration throughout the growing season, (b) determine the leaf N-sufficiency level, and (c) relate the growth rate constants and leaf N concentrations to sugarcane yields.

The N-sufficiency level is defined as the minimum leaf N concentrations at different times during the growing season that would produce optimum growth. Very little increase in cane yields would be expected from higher N concentrations, but they might retard maturity.

METHODS

Sugarcane variety NCo 310 was planted on Hidalgo sandy clay loam (Tupic Calcuttolls) in 1971. The surface foot of this soil has a moderate organic matter content (1.6%), a low total N content (0.08%), a pH of 8.0, and a CaCO_3 equivalent of 2.8%. The soil's capacity to supply $\text{NO}_3\text{-N}$ is high as indicated by a N-index of 7.8 (9).

The experimental design was a randomized complete block with four replications. Each plot consisted of six 25-ft long rows of cane spaced 6 ft apart. Nitrogen, as NH_4NO_3 , was applied at rates of 0, 50, 100, 150, and 200 lb/acre/yr. Of the total amount of N, 25, 25, and 50% were applied in January or February, March, and April, respectively, beginning in 1972. The fertilizer was broadcast and mixed with the soil by cultivating with a two-row Lilliston. Foliar tests in June 1974 indicated that the leaf N concentration was below the critical level; therefore, an additional 50 lb N/acre was applied to all previously fertilized plots.

Leaves and sheaths numbered 3 through 6, counting the spindle leaf as No. 1, were collected from five stalks in each plot eight times during the growing season. The 20 sheaths were separated from the leaves at the dewlap, sealed in a plastic bag, and transported to the laboratory

for moisture determinations. The middle third of the leaf blade was removed, cleaned with a mild detergent solution, and rinsed in distilled water. The midribs were stripped out, and the remaining leaf tissue was dried, ground to a fine powder, and analyzed for total N.

Growth of five primary stalks in plots treated with 0, 100 and 200 lb N/acre was measured at approximately 2-week intervals from May until the cane lodged in August 1974 or September 1973. A metal plate at the base of the stalk marked the ground level, and the top visible dewlap was the uppermost reference point.

Soil water was measured on selected plots during the growing season using the neutron scattering technique. Access tubes were installed in plots treated with 50 and 150 lb N/acre, and then water content was measured at 1-ft increments to a 5-ft depth. All plots were irrigated when the measured water content indicated that 60% of the available water in the surface 3 ft had been used.

Total precipitation in 1972, 1973, and 1974 of 33.2, 43.1, and 22.6 in/yr, respectively, was supplemented by six, four, and eight applications of irrigation water. Approximately 4 acre-in of water was applied each irrigation. During the irrigation season (climatological weeks 9 through 27) the corresponding precipitation was 20.6, 28.0, and 5.1 in, respectively. Climatological week number 1 is March 1-7, inclusive.

Cane was hand harvested from 20 ft of the two center rows in December 1972 and 1974 and January 1973. The number of millable stalks and total cane yields were determined. Juice of 20 stalks from each plot was analyzed for total soluble solids and apparent sucrose (7).

In presenting the data, sampling dates were altered to conform with the U.S. Weather Bureau's nearest climatological week. Seasonal precipitation was calculated for periods corresponding with climatological weeks.

Soil samples were collected from all plots after the growing season, and analyzed for $\text{NO}_3\text{-N}$. Depths of sampling were 0 to 1, 1 to 2, and 2 to 3 ft.

Regression techniques were used to determine relations among the parameters: cane age, stalk length, leaf N concentration, leaf sheath moisture, juice quality, and yields of cane and sugar.

RESULTS

Growth Rate

Cane growth during climatological weeks 11 through 27 was described as a function of time (t weeks) by the regression model:

$$Y = a + bt$$

where Y is stalk length (in.), and the regression coefficient (b) the growth rate per unit of time. Nitrogen fertilization significantly increased the mean growth rates of the second (1973) and third (1974) ratoon crops (Table 1) and the daily growth rate for certain sampling dates (Fig. 1). Differences in the mean growth rates indicate differences in cane production. During climatological week 16 in 1973, sugarcane fertilized with 0, 100, and 200 lb N/acre attained maximum growth rates of 0.89, 1.29, and 1.15 in/day, respectively. The duration of the periods of rapid growth was not affected by the N-fertilization rates. The trend of the curves during the mid-May through August period was apparently influenced by other than N factors.

Table 1. Effect of N fertilizer on growth rate of sugarcane.

N-rates		Growth rates		Correlation coefficients	
1973	1974	1973	1974	1973	1974
lb/acre		in./wk ¹			
0	0	4.68 a*	2.99 a	0.992**	0.996**
100	150	5.55 b	4.33 b	0.987**	0.988**
200	250	5.78 b	4.72 b	0.991**	0.990**

¹Climatological weeks 11 through 27.

*Values in same column followed by same letter not significantly different at 5% probability level by Duncan's Multiple Range Test.

**Significant at 1% probability level.

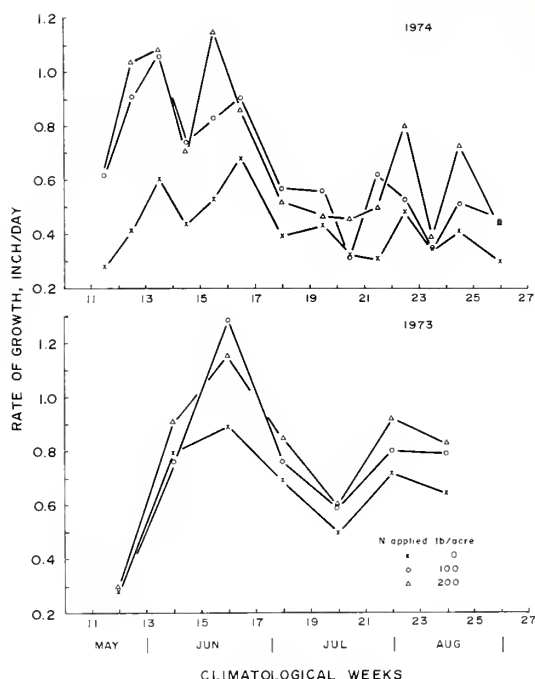


Fig. 1. Daily rate of elongation of sugarcane stalks as affected by rate of N fertilization and age of sugarcane in 1973 and 1974.

Although not investigated *per se*, the availability of water was an important factor affecting growth response of sugarcane to N fertilization. The relation between availability of soil water, N, and growth was readily seen in 1974, where, before an irrigation during climatological week 15, growth rates for the 0, 100, and 200 lb N additions were 0.44, 0.74, and 0.71 in./day, respectively. The corresponding growth rates a few days after irrigation were 0.58, 0.83, and 1.15 in./day, but declined to 0.40, 0.57, and 0.52 in./day by climatological week 18. During this period (climatological weeks 15 to 18) approximately 60% of the available soil water was used (Fig. 2). These low growth rates were maintained for a short period after irrigation in climatological week 18, then they further decreased to 0.32, 0.31, and 0.46 in./day during the next soil drying cycle (climatological weeks 18 to 21). The relationship between growth rate and available soil water was not readily apparent in 1973, since the normal soil-drying cycles between irrigations were interrupted by rain. However, the decrease in growth rate between climatological weeks 18 and 20 was closely associated with a decrease in available soil water.

Leaf Sheath Moisture Content

Moisture of leaf sheaths (Fig. 3) showed no response to N fertilization in 1972, but in 1973 and 1974 the moisture percentage of the leaf sheaths and the rate at which their moisture content decreased with maturity of the sugarcane were affected by N fertilization. In 1973 the sheath moisture content decreased gradually until climatological week 28. The rapid decrease in sheath moisture after this date was associated with a decrease in the available soil water. Similarly in 1974, the rapid decrease in sheath moisture content of the fertilized cane between climatological weeks 13 and 20 was due partly to available soil water and to low N concentration in the leaf. The relation between sheath moisture (Y) and leaf N content (X) at harvest 1974 as given by the regression equation

$$Y = 50.85 + 19.64X$$

was highly significant ($r = 0.85^{**}$). Similar relations were found for earlier sampling dates. Cane deficient in N had low sheath moisture content regardless of the soil water condition.

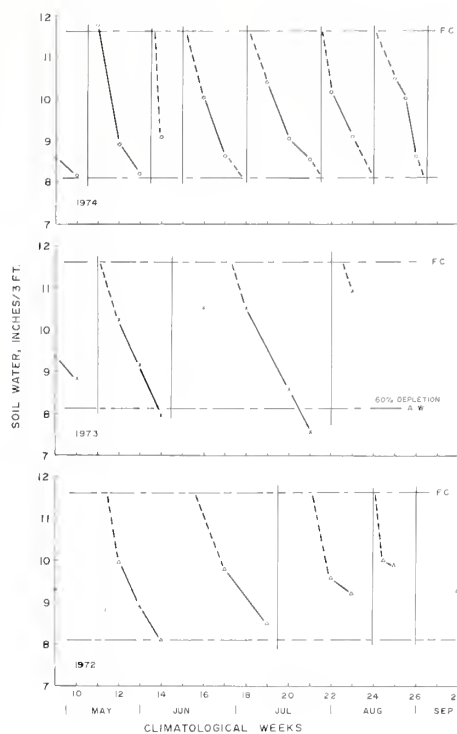


Fig. 2. Soil water depletion curves. Irrigation water was applied when 60% of available water (AW) in surface 3 ft used. FC, field capacity, (—) soil water change after irrigation, (---) assumed water depletion curve before first neutron reading.

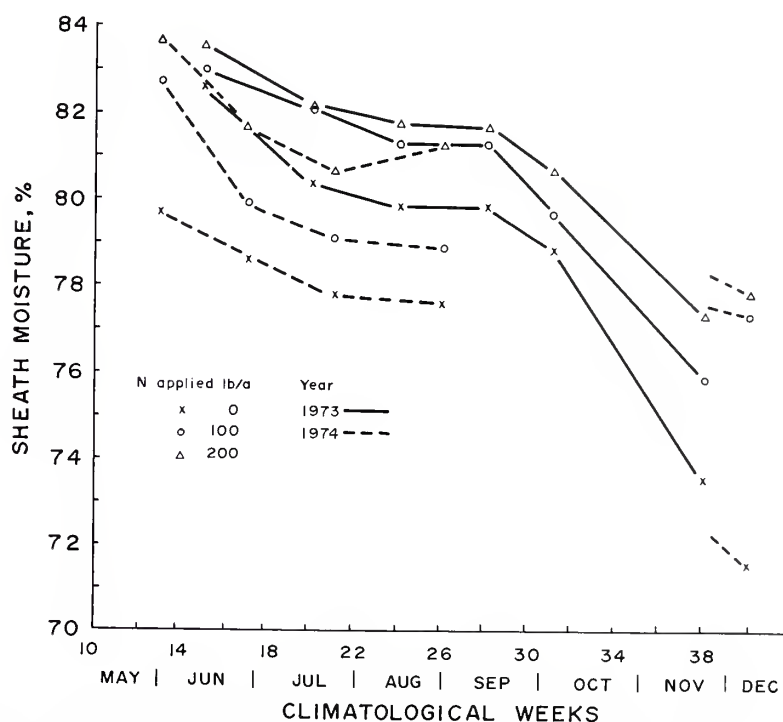


Fig. 3. Moisture content of leaf sheaths as affected by sugarcane age and rate of N fertilization in 1973 and 1974.

Leaf Nitrogen Content

The N concentration in the sugarcane leaves varied greatly with the amount of fertilizer, year applied, and sugarcane age (Fig. 4). Yearly differences in the N concentration of the same aged cane were associated with differences in availability of soil N. Nonfertilized sugarcane in 1972, 1973, 1974 had leaf N concentrations of 1.93, 1.65, and 1.43%, respectively, in climatological week 16. Soil analysis of the nonfertilized plots after the 1972 and 1973 seasons showed available $\text{NO}_3\text{-N}$ levels of approximately 4 and 1 lb/acre, respectively, in the surface foot. The N concentration of leaves generally decreased as the cane matured. However, in 1972 and 1973, the concentration increased late in the season after vegetative growth had virtually ceased.

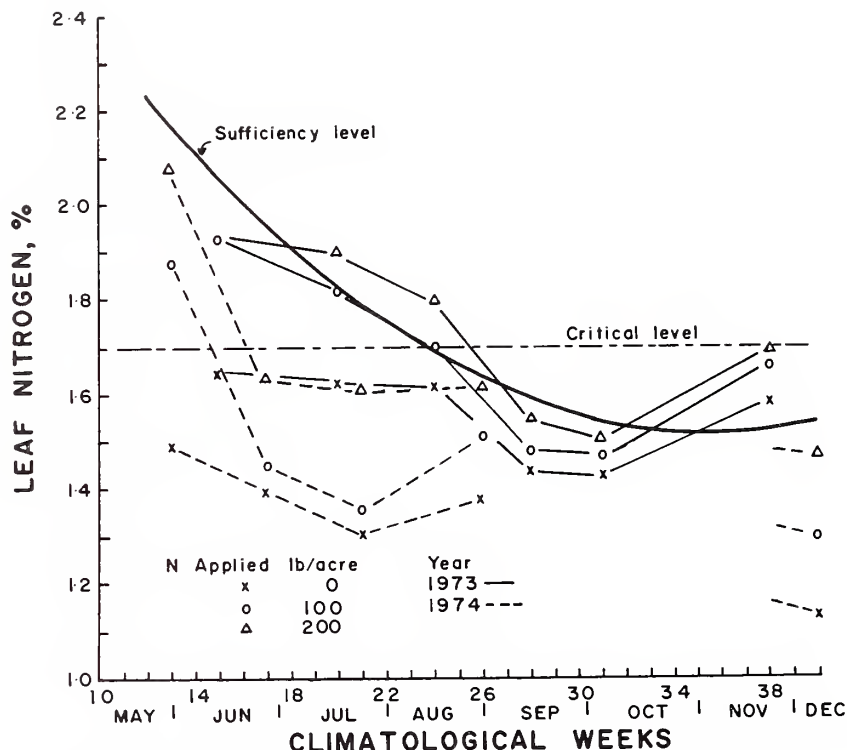


Fig. 4. Nitrogen concentration of leaves as affected by N fertilization rates and age of sugarcane in relation to N sufficiency level and N critical level.

The critical leaf N concentration of 1.7% was estimated from the relation between sugarcane yields and the N concentration of the leaves during climatological weeks 15 and 13 of 1973 and 1974, respectively (Fig. 5). In the leaf N concentration range 1.2 to 1.6%, yield increases were nearly proportional to the amount of N absorbed. Above a leaf N value of 1.8%, minor changes in yield were associated with a relatively large range of leaf N values. Visual symptoms of N deficiency were noted at leaf N concentrations near 1.4%.

To attain optimum cane yields, the leaf N concentration must be higher than the critical level during the boom stage of growth (climatological weeks 12 to 26). However, since high N levels delay cane ripening (Fig. 6), N should become deficient as plants approach maturity. The leaf N concentrations needed to achieve optimum yields and maximum sugar production are shown by the N sufficiency curve (Fig. 4).

The N sufficiency level was described by the second-degree polynomial equation:

$$Y = 3.12 - 0.0897X + 0.00126X^2,$$

where Y represents the desired N concentration (%) of the leaves at time X (climatological week). The correlation coefficient ($R = 0.914^{**}$) was highly significant. Leaf N data from the nonfertilized cane in 1972 and cane treated with 100, 150, and 200 lb N/acre in 1973 were used to develop the N sufficiency curve.

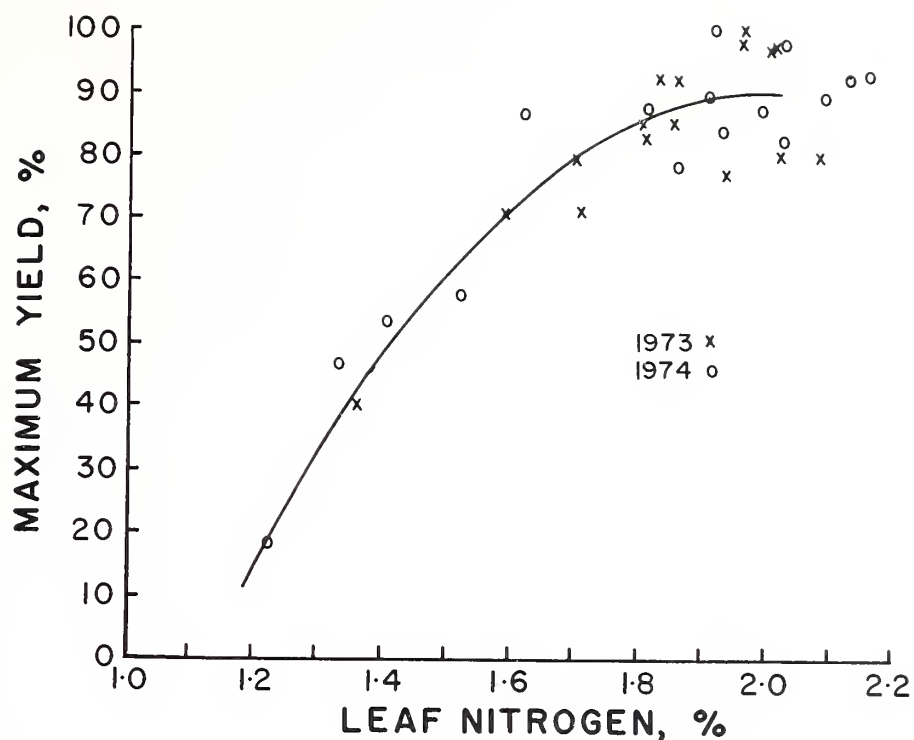


Fig. 5. Relation of relative sugarcane yields to the N concentration of leaves during climatological weeks 15 and 13, of 1972 and 1973, respectively.

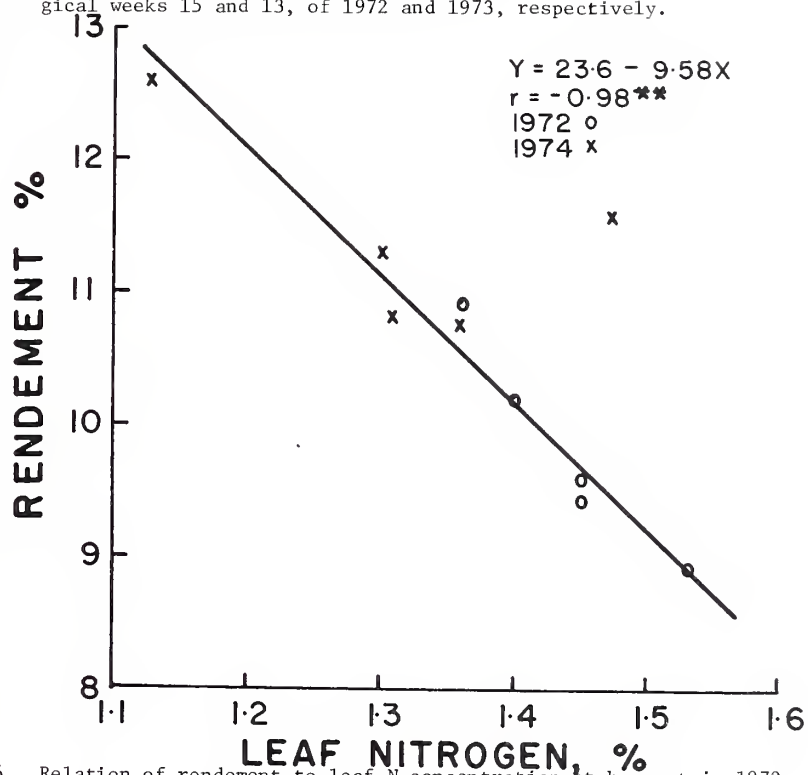


Fig. 6. Relation of rendement to leaf N concentration at harvest in 1972 and 1973.

The leaf N concentration of the third ratoon crop (1974) was below the sufficiency level at the beginning of the growth period and rapidly dropped below the critical N level (Fig. 4). The 50 lb N/acre supplement in climatological week 18 failed to increase the N concentration to the desired level.

Yield

No significant yield response to N fertilizer was obtained with the first ratoon crop (Table 2). However, with the second (1973) and third (1974) ratoon crops, the first 100-lb increment of N significantly increased sugar and cane yields over the nonfertilized treatment. Except for the 1972 crop, the amount of fertilizer significantly affected stooling (indicated by the number of millable stalks), internode length, and weight per stalk. The 1974 application of 0, 100, and 200 lb N/acre resulted in average internode lengths of 4.4, 5.0, and 5.2 in., respectively. Corresponding stalk weights were 1.41, 2.13, and 2.58 lb. Applying an additional 50 lb of N in 1974 probably had little effect on cane yields, since the growth rates (Fig. 1) and the leaf N concentrations (Fig. 4) continued to decline. Evans (2) stated that an "application of supplementary N rarely gives an increase in tonnage unless it results in an increase in the leaf N index."

Table 2. Sugarcane yields and juice quality as affected by N fertilization.

N applied	Year	Yields of		Millable stalks	Brix	Purity	Pol
		Cane	Sugar				
		ton/acre		No./acre		%	
0	1972	60.4 a	6.0 a	49,391 a ¹	17.8 a	80.5 a	13.8 a
50		56.8 a	6.1 a	52,423 a	18.6 a	82.5 a	15.0 a
100		57.6 a	5.4 a	49,398 a	17.8 a	81.5 a	13.4 a
150		52.6 a	4.8 a	50,911 a	17.8 a	80.7 a	13.2 a
200		56.7 a	5.2 a	50,820 a	17.7 a	79.2 a	12.8 a
0	1973	41.9 a	4.1 a	32,097 a	16.6 a	80.8 a	13.5 a
50		49.4 ab	4.7 ab	37,480 b	16.6 a	80.7 a	13.5 a
100		52.8 b	5.1 ab	40,429 bc	16.4 a	81.3 a	13.4 a
150		53.3 b	5.1 ab	43,016 cd	16.7 a	80.4 a	13.5 a
200		58.8 b	6.0 b	46,691 d	17.2 a	82.9 a	14.3 a
0	1974	23.7 a	2.9 a	32,852 a	19.0 a	89.0 a	16.9 a
50 + 50 ²		44.7 b	4.8 b	41,065 b	17.0 b	86.8 a	14.8 b
100 + 50		48.8 b	5.5 b	45,874 bc	17.9 ab	86.3 a	15.4 ab
150 + 50		51.4 b	5.5 b	48,869 c	17.3 ab	85.3 a	14.8 b
200 + 50		50.1 b	5.8 b	56,628 d	18.1 a	86.6 a	15.7 ab

¹Values in same column followed by same letter not significantly different at 5% probability level by Duncan's Multiple Range Test.

²Supplementary N application.

No significant differences in brix, sucrose (pol), or purity of the sugarcane juice were measured between treatments, except in 1974, when the effects of fertilizer on brix and sucrose were significant but not consistent. Juice purity and sucrose content were significantly greater in 1974 (a dry season) than in 1972 and 1973 (wet seasons). The relatively low purities (1972-73) are associated with a high N concentration in the plant and with the early harvest of this variety. In 1973 the air temperature dropped to 26F on December 20 (climatological week 43) about 18 days before harvest. However, air temperatures remained cool after the freeze, and deterioration in juice quality was slight.

DISCUSSION

The relationship between sugarcane yields (Y) and the growth rate constants (X), as described by the regression equation $Y = 11.50X - 7.72$, was highly significant and accounted for 86% of the yield variability. The regression coefficient suggests that within the plant population range 32,000 to 56,000 millable stalks/acre an increase in the mean rate of stalk elongation by 1 in./wk during the May through August growth period increased the estimated yield by 11.5 ton/acre. Since the daily growth rate was affected more by the availability of soil water than by the rate of N

fertilization, more frequent irrigations than those used in this study, especially in June and July, should maintain higher growth rates over longer time periods and result in higher sugarcane yields.

The relation between the second and third ratoon sugarcane yields and the N concentration of the leaves was best described by second-degree polynomial equations (Table 3). Coefficients of determination ($R^2 \times 100$) indicate that the leaf N concentration in climatological weeks 14 and 19 accounted for 86 and 44%, respectively, of the variability in yield. Yields are expressed as a percentage of the maximum yield obtained each year. The equations also predict that with leaf N concentrations of 1.98 and 1.77% during these sampling periods, respectively, sugarcane yields should be approximately 90% of maximum. Apparently, the critical N level changed as the sugarcane aged, even though leaves of the same physiological age were collected. Assuming that the critical level is associated with a 10% reduction in yield from the 90% of maximum level, critical leaf N values were approximately 1.7 and 1.5% during climatological week 14 and 19, respectively.

Juice quality was significantly ($r = -0.91^{**}$) affected by the moisture content of the plant at harvest, as shown by the relation between pol percentage (Y) and sheath moisture content (X) of the third ratoon crop,

$$Y = 36.74 - 0.277X.$$

The regression coefficient indicates that a 1% increase in sheath moisture content decreased pol by 0.28%.

An application rate of 100 lb N/acre seems to be optimum. However, the sharp decrease in yields of the nonfertilized cane, and the relatively low leaf N concentration of the 100-lb N/acre fertilized cane in May 1974, indicates that the soil's capacity to supply N was decreasing, and suggests that the amount of N applied to older ratoon crops should be increased. Failure of the 50 lb/acre supplementary N application to increase yields seems to reflect the timing of the application.

Table 3. Regression equations relating sugarcane yields (Y%) to the N concentration (X) of the leaves at two sampling periods.

Climatological week	$Y = b_0 + b_1X + b_2X^2$	S_y	R
14	$Y = -396.48 + 491.35X - 124.02X^2$	+7.4	0.927**
19	$Y = -301.21 + 444.34X - 125.748X^2$	+14.7	0.662**

Yields expressed as percentage of maximum yield

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THE EFFECT OF FERTILIZERS AND SOIL VARIABILITY
ON SUGARCANE YIELD AND ITS COMPONENTS

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ABSTRACT

An experiment was conducted on Loring-Olivier silt loam, with a surface slope of approximately 3%, to determine the effect of fertilizer treatments and soil variation on sugarcane yield and its components. Fertilizer N, P, K and S and soil type were variables in the experiment. Data were obtained from plant and first stubble crops. The effect of fertilizers on sugarcane yield and the yield components, number, length and weight of millable stalks, was generally less than the effect of soil variation on yield and yield components. There was a general increase in yield from plant and stubble cane due to fertilizer N at rates up to 160 lb per acre. Fertilizer P, K and S did not significantly influence yield of plant cane. Fertilizer P resulted in a significant increase in yield of stubble cane. Cane yield was greatest on the lower portion of the area, least on the upper portion and intermediate between the lower and upper portions of the area. Generally the cane yield was related more to depth of topsoil than to soil chemical properties. Correlations between cane yield and each of the yield components, number, mean length and mean weight of millable stalks were highly significant in both plant and stubble crops and were of the order: number > mean length > mean weight. Mean diameter of millable stalks was not significantly related to cane yield.

INTRODUCTION

The effect of fertilizers applied to different soil types on yield of sugarcane in Louisiana has been reported by several workers (1, 2, 4, 6, 12, 14). Sugarcane yield increases due to fertilizer N, P and K were reported throughout the cycle of plant and stubble crops and were generally of the order: plant cane > first stubble > second stubble. Yield increases due to fertilizer P and K were normally greater in experiments on older alluvial or terrace soils located in the Bayou Teche area than in experiments on Recent Mississippi alluvial soils. The earlier experiments were conducted at sites with surface slopes which were generally less than 1% and with minimum soil variability.

Relatively recent studies of associations between yield of sugarcane and its components have been made in Louisiana by Hebert (7), Henderson, Legendre and Viator (8), Legendre (9), Ricaud (11) and Golden (3). Generally, correlations were moderately high to high between yield of cane per acre and each of the yield components, number of stalks per acre and mean length of stalks. Correlations between cane yield per acre and mean weight of stalks were generally intermediate and correlations between yield of cane per acre and mean stalk diameter were generally low.

The purpose of this study was to determine the relationship of fertilizer treatments and soil variation within the experimental area to sugarcane yield and its components. Yield and nutrient element contents of roots and below-ground stubble from plant cane grown in the experiment were reported earlier (5).

MATERIAL AND METHODS

An experiment was conducted with L 60-25 plant and first stubble cane in 1970 and 1971 on a soil with a surface slope of approximately 3% at the Perkins Road Agronomy Research Farm in East Baton Rouge Parish. The soil varied from Loring silt loam on the upper part of the slope (Replicate or Soil I) to Loring-Olivier silt loam (Replicate or Soil II) to Olivier silt loam on the lower part of the slope (Replicate or Soil III). For a period of many years prior to 1970, various field crops had been grown on the site. Although sugarcane is not grown commercially in East Baton Rouge Parish, a substantial acreage is produced on Loring and Olivier soils in Lafayette Parish and parishes adjacent to Lafayette Parish.

Sugarcane was planted in the experimental site on October 3, 1969, at the rate of three continuous stalks with an overlap of approximately 15%. The seed cane, considered to be disease free, was obtained from Rapides Parish.

Gradient of rows, which were prepared at a right angle from the direction of the prevailing slope, was less than 1/2%.

The fertilizers were applied early in April of each crop year. Nine fertilizer treatments were established in each replicate. There were six rows in each replicate with each plot consisting of three rows 35 ft in length. The center row of each plot was used for shoot and stalk counts during the growing seasons and for yield data at harvest.

The number of shoots and stalks was determined each crop year on seven different dates during the period April through August. In September of each crop year, an estimate of the number of millable stalks was made, and, in October of each crop year, the number of millable stalks was determined.

At harvest, stalks were cut at the topmost mature joint or approximately 20-22 inches from the top visible dewlap, which was 8-10 inches below the growing point. Stalks not measuring 3 ft or more in length following removal of tops were discarded. The weight of millable stalks was determined by bulk weighing following the removal of trash. Length and diameter were determined for each stalk individually.

RESULTS AND DISCUSSION

Yield and yield-component data from the fertilizer treatments and different soils are shown in Table 1. The data show that differences in yield and its components due to soil variation were generally larger than differences due to fertilizers. The relatively small number of significant differences among fertilizer treatments was apparently due, in part, to soil variation within replicates.

Table 1. Yield and yield components of sugarcane as related to fertilizer treatment and soil variation.

Treatment variable				Cane yield		Millable stalks		Stalk length		Stalk weight		Stalk diam	
N	P ₂ O ₅	K ₂ O	S	Pl	St	Pl	St	Pl	St	Pl	St	Pl	St
Lb/A				Net tons/A		No./A		Inches		Lb/stalk		Inches	
0	0	0	0	28.63	25.93	29,020	35,420	73.3	67.4	1.96	1.45	1.02	1.03
80	0	0	0	31.11	27.27	30,160	36,910	72.5	63.3	2.06	1.45	1.04	1.06
160	0	0	0	33.37	29.72	33,860	40,970	76.2	64.3	1.97	1.46	1.02	1.10
240	0	0	0	32.82	28.83	33,210	28,620	78.5	68.5	1.97	1.50	0.98	1.03
240	40	0	0	31.72	35.71	30,510	45,660	76.0	74.9	2.07	1.57	1.01	1.02
240	0	0	24	30.98	27.86	32,080	35,850	74.5	68.6	1.92	1.55	0.98	1.02
240	0	80	0	32.27	31.31	31,720	42,030	74.4	69.4	2.02	1.49	0.99	1.01
240	0	80	24	31.47	32.09	31,650	42,040	74.7	72.6	1.95	1.53	1.00	1.07
240	40	80	24	31.51	37.24	31,220	43,960	73.6	67.0	2.02	1.69	1.04	1.09
LSD 0.05:				4.48	4.48	NS	5,640	NS	NS	NS	NS	NS	NS
Soil I				26.34	25.35	28,140	33,480	69.6	64.8	1.88	1.50	1.00	1.06
Soil II				30.22	30.89	30,840	41,910	73.3	66.7	1.95	1.47	1.02	1.08
Soil III				38.06	35.74	35,510	45,020	81.6	73.8	2.15	1.59	1.00	1.00
LSD 0.05:				3.29	3.29	3,040	3,040	4.1	4.1	0.12	0.12	NS	0.04

The data in Table 1 show a general increase in yield by plant and stubble cane due to fertilizer N at rates up to 160 lb per acre. The P and K extractable from the soil were very low (Table 2); however, no significant effect of these nutrients on yield of plant cane was noted. From a comparison of fertilizer treatments 4 and 5, it may be noted that fertilizer P resulted in a significant increase in yield by stubble cane. The S extractable from the soil was high (Table 2) and did not appear to influence yields of plant and stubble cane in the experiment. From the data presented showing yields from treatments which included N at the rate of 240 lb per acre, it appears that the high yield of stubble cane obtained in fertilizer treatment 9 was due primarily to P and, to some degree, to K.

Table 2. Results from analysis of soils.

Variable	Soil number		
	I	II	III
Organic matter, %	0.81	0.75	0.75
Extractable P, ppm	20	23	31
Extractable K, ppm	42	40	45
Extractable Ca, ppm	551	500	530
Extractable Mg, ppm	184	104	120
Extractable S, ppm	17	16	19
pH	4.8	4.8	4.9
Topsoil depth, inches	5.1	5.8	7.4

It may be noted in Table 1 that cane yields from both plant and stubble crops increased progressively in the order: Soil I < Soil II < Soil III. Results from analysis of soils (Table 2) show that the small differences in soil organic matter, in pH and in extractable K, Ca, Mg and S were not related to cane yield among soils. Extractable P values were generally associated with cane yield among soils.

The direct relationship between topsoil depth (Table 2) and cane yield among soils (Table 1) indicates that cane yields were due, to a substantial degree, to depth of topsoil and the inferences usually associated with the amount of topsoil (10, 13). Normally, conditions are better in topsoil, as compared with subsoil, for plant growth due to better soil air, water and nutrition relationships which directly influence root activity (10).

The trends of the number of millable stalks and stalk length and weight as influenced by fertilizer and soil variables were similar to trends in yield (Table 1). Stalk diameter of plant cane, however, was not significantly influenced by the variables but the average stalk diameter of stubble cane on Soil III was significantly smaller than the average stalk diameter of stubble cane on Soils I and II.

Tables 3 and 4 contain correlation coefficients (r) showing relationships among yield, shoot, and stalk data obtained from plant and first stubble cane. Consistently high positive correlations were found between cane yield and the number of shoots and stalks for the third through seventh determinations or counts in both plant and first stubble cane. The correlation coefficients between the September estimate of millable stalks (eighth count) and cane yield were relatively low. The correlations between cane yield and the number of millable stalks at harvest (ninth count) of plant and first stubble cane were 0.924 and 0.927, respectively. The correlation between cane yield and mean length of millable stalks of plant and first stubble cane were 0.817 and 0.682, respectively. The negative association between mean stalk diameter and mean length of first stubble cane, -0.392, was the only significant relationship found between stalk diameter and other variables shown in Tables 3 and 4.

Table 3. Simple correlation coefficients (r)^{1/} among yield, shoot, and stalk data obtained from plant cane grown on Loring-Olivier silt loam in 1970^{2/}.

Count:	No. of shoots (sht) and/or stalks (stk)									Stalk		
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	Length	Weight	Diam.
Cane yield	.244	.610	.842	.853	.853	.824	.855	.656	.924	.919	.817	.026
Sht & stk - 1st		.851	.533	.465	.497	.355	.357	.214	.222	.261	.198	.150
Sht & stk - 2nd			.860	.850	.757	.705	.734	.528	.568	.593	.483	.030
Sht & stk - 3rd				.974	.943	.915	.947	.712	.760	.799	.713	-.003
Sht & stk - 4th					.964	.926	.944	.772	.776	.778	.708	.047
Sht & stk - 5th						.968	.956	.826	.808	.820	.664	-.048
Sht & stk - 6th							.970	.824	.808	.796	.601	-.149
Sht & stk - 7th								.774	.807	.805	.675	-.061
Stk - 8th									.744	.543	.321	-.212
Stk - 9th										.819	.538	-.156
Stk length											.818	-.023
Stk weight												.295

^{1/} Least significant r at 1% level = .487.
Least significant r at 5% level = .381.

^{2/} Data correlated were cane yields in net tons per acre, number of shoots and stalks at counting periods 1 through 7, estimate of number of millable stalks (8th count), number of millable stalks (9th count) and mean length, weight and diameter of millable stalks.

Table 4. Simple correlation coefficients (r)^{1/} among yield, shoot and stalk data obtained from first stubble cane grown on Loring-Olivier silt loam in 1971^{2/}.

Count:	No. of shoots (sht) and/or stalks (stk)									Stalk		
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	Length	Weight	Diam.
Cane yield	.380	.445	.723	.677	.711	.723	.764	.574	.927	.720	.682	-.126
Sht & stk - 1st		.908	.588	.501	.507	.331	.312	.379	.411	.426	.124	-.282
Sht & stk - 2nd			.753	.688	.684	.536	.491	.536	.533	.418	.050	-.199
Sht & stk - 3rd				.927	.921	.790	.785	.797	.774	.631	.264	-.245
Sht & stk - 4th					.993	.824	.805	.731	.760	.571	.184	-.117
Sht & stk - 5th						.832	.826	.728	.785	.591	.232	-.105
Sht & stk - 6th							.982	.822	.815	.531	.214	-.105
Sht & stk - 7th								.822	.828	.587	.307	-.151
Stk - 8th									.659	.523	.142	-.265
Stk - 9th										.629	.369	-.102
Stk length											.593	-.392
Stk weight												-.146

^{1/}Least significant r at 1% level = .487.

Least significant r at 5% level = .381.

^{2/}Data correlated were cane yields in net tons per acre, number of shoots and stalks at counting periods 1 through 7, estimate of number of millable stalks (8th count), number of millable stalks (9th count) and mean length, weight and diameter of millable stalks.

Fig. 1 through 4 show the number of plant and first stubble shoots and/or stalks per acre as related to time, selected fertilizer treatments and soil type. The curves show the number of shoots and stalks determined during the period May through August of each year. Results from data obtained in April were omitted. The points on the curves representing the September counts reflect estimates of the number of stalks that possibly would be millable. In October, the actual number of millable stalks was determined.

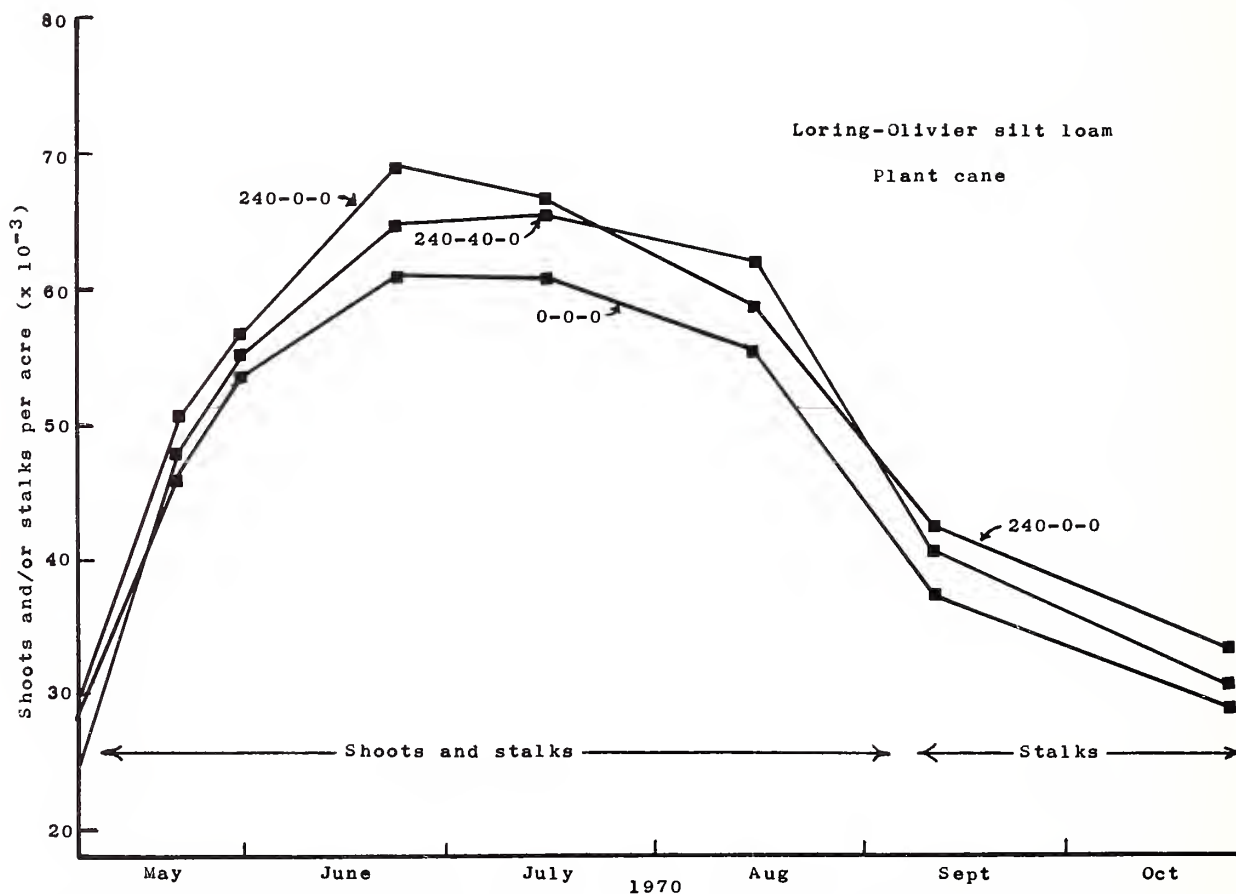


Fig. 1. The number of shoots and/or stalks per acre as related to time and fertilizer treatment.

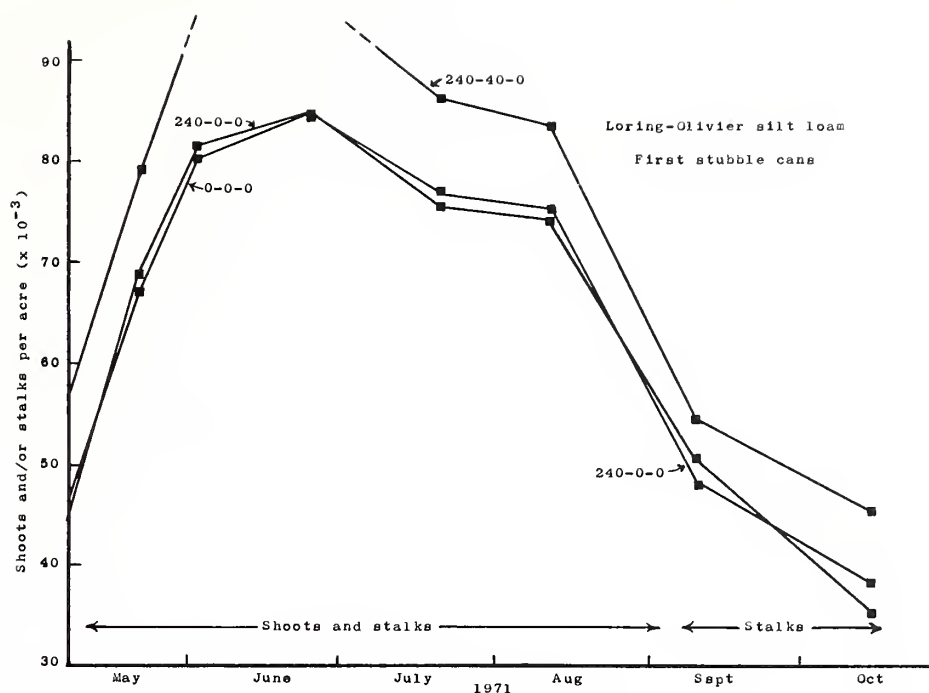


Fig. 2. The number of shoots and/or stalks per acre as related to time and fertilizer treatment.

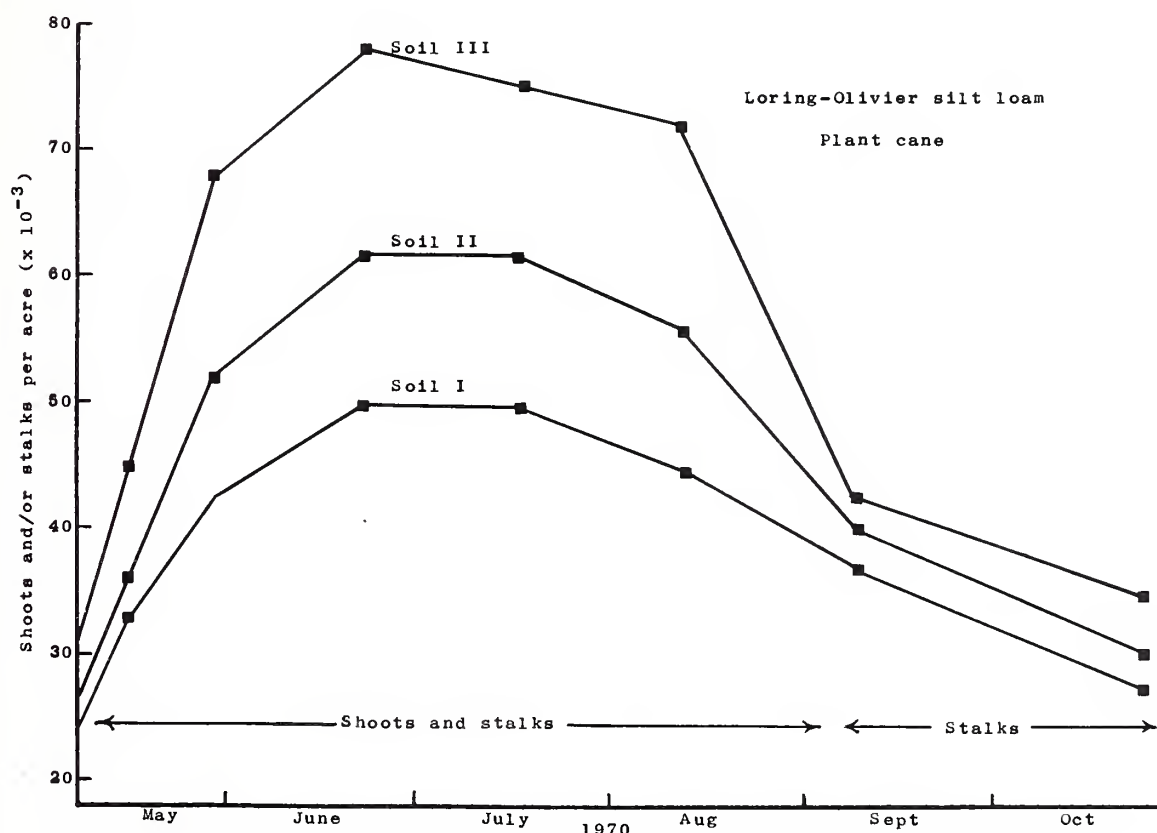


Fig. 3. The number of shoots and/or stalks per acre as related to time and soil variation.

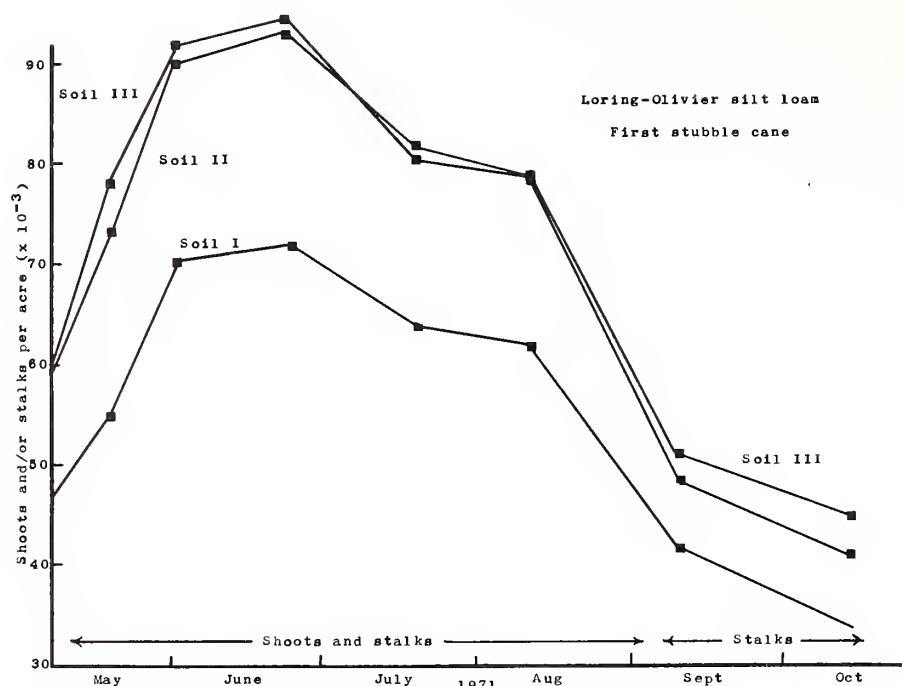


Fig. 4. The number of shoots and/or stalks per acre as related to time and soil variation.

It can be seen in Fig. 1 that the number of plant cane shoots and stalks found in plots treated with 240-0-0 was consistently higher than the number in the check (0-0-0 treatment). The relatively high number of shoots and stalks found in August on plots which received the 240-40-0 treatment apparently was due to an increase in the number of late tillers which, however, failed to reach the required height to become millable cane. The larger number of shoots and stalks throughout the first stubble growing season in plots treated with 240-40-0 was apparently perpetuated by the P in the second application of 240-40-0 which was applied at the beginning of growth of the first stubble crop.

Generally, differences in the number of shoots and stalks due to soil variation (Fig. 3 and 4) were much greater than differences due to fertilizers (Fig. 1 and 2). During plant cane growth (Fig. 3), the differences between Soil I and II were approximately equal to differences between Soil II and III. During stubble cane growth (Fig. 4), the number of shoots and stalks on Soil I was consistently low and differences between Soils II and III were not found until the determination of the number of millable stalks was made at harvest.

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PREDICTING DELIVERY RATES AND ECONOMICS OF
TRANSPORTING SUGARCANE TO THE MILL

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ABSTRACT

Interest in the chopper harvester machine in Louisiana and other areas has accentuated the need for a method to compare various loading and transporting systems. A study was formulated to develop a mathematical model based on field time and motion data, by which it would be possible to predict the delivery rate and cost per ton delivered to the mill. A cane transport system was simulated using IBM General Purpose Simulation System computer language, and a theoretical analysis was made applying queuing theory. The simulation was a factorial analysis of four independent variables: the number of transport units; the transport unit capacity; the mean loader rate; and the mean field-to-mill transport time. The relationships of the dependent variable, i.e., delivery rate, as affected by the independent variables are presented. A nomograph for a single loader system was developed for a direct solution with given values of the variables. A cost analysis made using the variables included in the delivery rate nomograph is based on fixed operating and labor cost categories. Separate mathematical models are developed for each category and then combined into a general cost equation. Examples of using the delivery rate nomograph and cost per ton delivered are presented.

Louisiana conditions generally require that sugarcane be cut 1/2 to 1 day ahead of the loader; it is then burned and transported to the mill. This type of harvesting system is essentially two independent systems, a harvester and a transport system. Recent interest in the cutter-chopper-loader type harvester has accentuated the need for a model which could be used to size transport units and determine the appropriate number for a combine harvesting system or analyze the transport phase of the conventional Louisiana system. The objective of this analysis was to develop a model from field data which would predict the delivery rate of cane to the mill for a given transport system and optimize the system based on cost of delivery in dollars per ton.

During 1973 several mills and transport systems were monitored to obtain actual values for loading rate, transport unit capacity, travel time, weighing and unloading time at the mill, and associated distributions. Transport system variables were identified as follows:

1. Loader or chopper harvester rate - tons/hour
2. Number of transport units
3. Capacity of each transport unit - tons
4. Field to mill distance - miles
5. Average speed of transport units - miles/hour
6. Mill time distribution, i.e. expected time a transport unit will stay at the mill as related to the time of day when it arrives at the mill
7. Service time distributions for the loader or chopper harvester, transport unit travel time, and total mill time
8. Probabilities of breakdowns for each transport unit and loader or chopper harvester
9. Mean breakdown time

Analysis of the transport system requires an estimate of the time the transport unit is absent from the field. This time consists of time enroute to and from the mill and waiting and service time at the mill. For this study the total time at the mill was used which combines individual waiting and service times. The remainder of the time away from the field is a function of field to mill distance and road speed.

Two concurrent approaches were used to develop a transport system model. A cane transport system was simulated using IBM General Purpose Simulation System language and a theoretical analysis applying queuing theory and adapting previous work by Shaffer (5).

The General Purpose Simulation System (GPSS) is a computer language which facilitates simulation of stochastic relationships among variables and provides realistic results when supplied with good estimates of means and their associated distributions. Such a GPSS computer program was written to simulate a single loader transport system. Verification was accomplished by simulating the operation of the Helvetia mill transport-handling system and comparing the simulated schedule of cane delivery to the mill with the observed, Fig. 1.

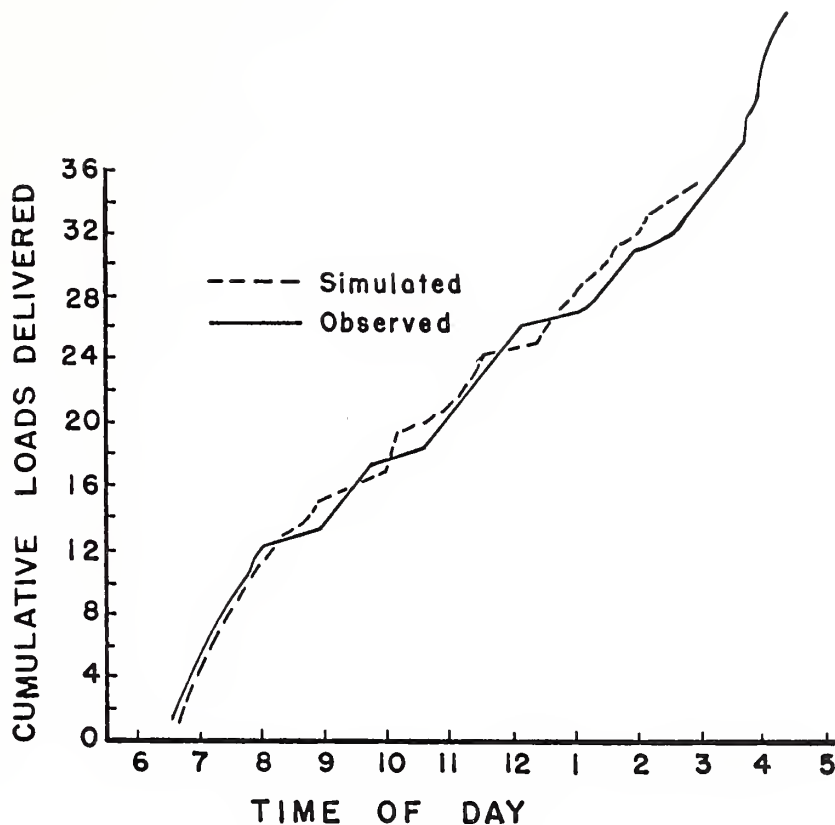


Fig. 1. Comparison of simulated with actual delivery to the Helvetia Mill.

Close agreement was obtained between the observed and simulated transport systems. After the GPSS computer model was verified, the analysis could be expanded to evaluate the operation of multiple loader systems, determine the effect of variations in number of transport units, predict loader idle time and transport unit field queue time, etc.

Fig. 2 and 3 were obtained as a result of the simulation. Fig. 2 indicates the relationship of mill delivery rate and loader rate for various numbers of transport units. For a given total trip time, the advantage of increasing the number of transport units decreases as more units are used. Deviation from the dashed 45° line indicates deviation from the maximum possible delivery rate.

The system delivery rate is related to the transport unit capacity in Fig. 3. For each loader rate, total trip time, and number of transport units, there is diminishing advantage to delivery rate through increased transport unit capacity.

Probably the easiest decision variable to manipulate in a cane transport system such as the one simulated is the number of transport units. Additional transport units help to increase the delivery rate for any given total trip time, but the increase becomes less significant as the number of units increases. On the other hand, total trip time fluctuation has less influence on delivery rate when more transport units are used.

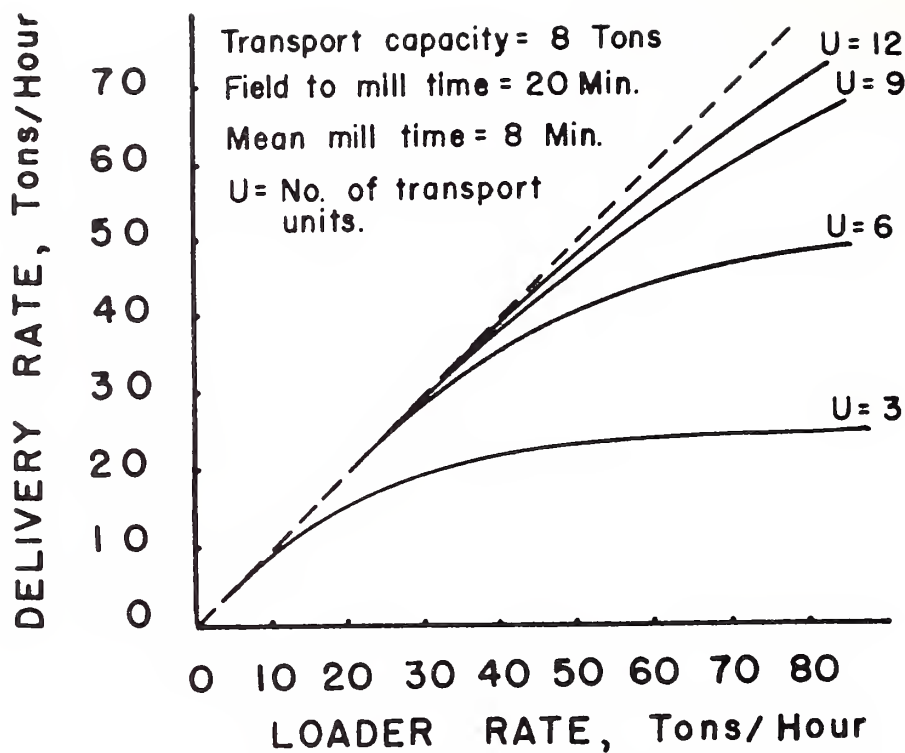


Fig. 2. Loader rate vs. delivery rate for varying number of transport units.

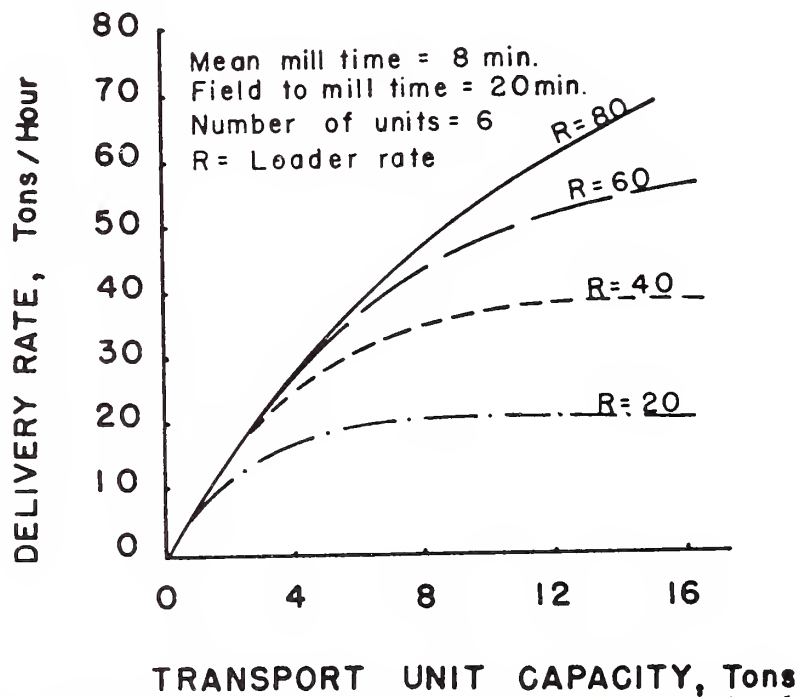


Fig. 3. Delivery rate as affected by transport unit capacity for various loader rates.

Previous efforts by Meliza (3), Shaffer (5), and others have resulted in theoretical analysis of queuing systems experienced in various construction operations. Their procedure using the theory of finite source was adapted to predict the delivery rate of sugarcane to the mill for some loader transport systems.

Fig. 4 presents an abstract of the type of transport system analyzed. Transport units arrive in the field and either begin loading or wait in queue. When loaded they depart the field, travel to the mill, dump, and return to the field. The delivery rate to the mill is given either by the average rate of loading transport units in the field or by the rate of hauling by the transport units. These two rates must be equal for steady state operation. Adapting from Meliza (3) and substituting appropriate variable symbols, the probability, (P_0), of no transport units in queue or loading (loader idle) is

$$P_0 = \left[1 + \sum_{q=1}^K \frac{U!}{(U-q)!} \left(\frac{1}{q!} \right) \left(\frac{1}{R/C} \right)^q + \sum_{q=K+1}^U \left(\frac{1}{K!} \right) \left(\frac{U!}{(U-q)!} \right) \left(\frac{1}{K^{q-K}} \right) \left(\frac{1}{R/C} \right)^q \right]^{-1}$$

where U = number of transport units in system
 T = trip time - field to mill (hrs.)
 C = capacity of transport units (tons)
 M = mill time for each trip (hrs.)
 R = loader rate (tons/hr.)
 and K = number of loaders.

SYSTEM ELEMENTS

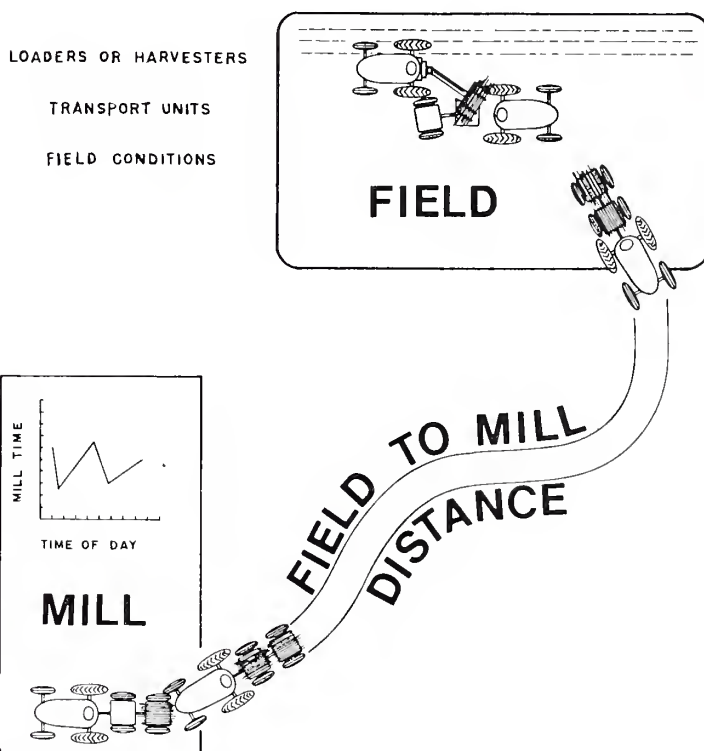


Fig. 4. Sugar Cane Transport System.

If transport units were constantly available at the field, the delivery rate could be predicted to equal the loader rate

$$D_e = R$$

However, a probability exists that part of the time all transport units will be absent from the field. The delivery rate is thus given by

$$D_e = R (1 - P_0)$$

where $(1 - P_0)$ is the expected fraction of time that at least one transport unit will be in queue or loading.

For single loader systems, the relationship for P_0 can be reduced to

$$P_0 = \left[\sum_{q=0}^U \frac{U!}{(U-q)!} \left(\frac{C}{R(2T+M)} \right)^q \right]^{-1}$$

By combining the results of the simulation model and the theoretical analysis, the effect of each parameter on delivery rate can be related by a nomograph, Fig. 5. The nomograph permits a graphical prediction of delivery rates for given values of transport unit capacity "C" (tons), average loader rate "R" (tons/hr.), total trip time "TTT" (hrs.), and the number of transport units "U". (Total trip time is approximated by the sum $2T+M$). Values of any parameter may be obtained given values of the other parameters. Similar graphs may be constructed for multiple loader systems if desired.

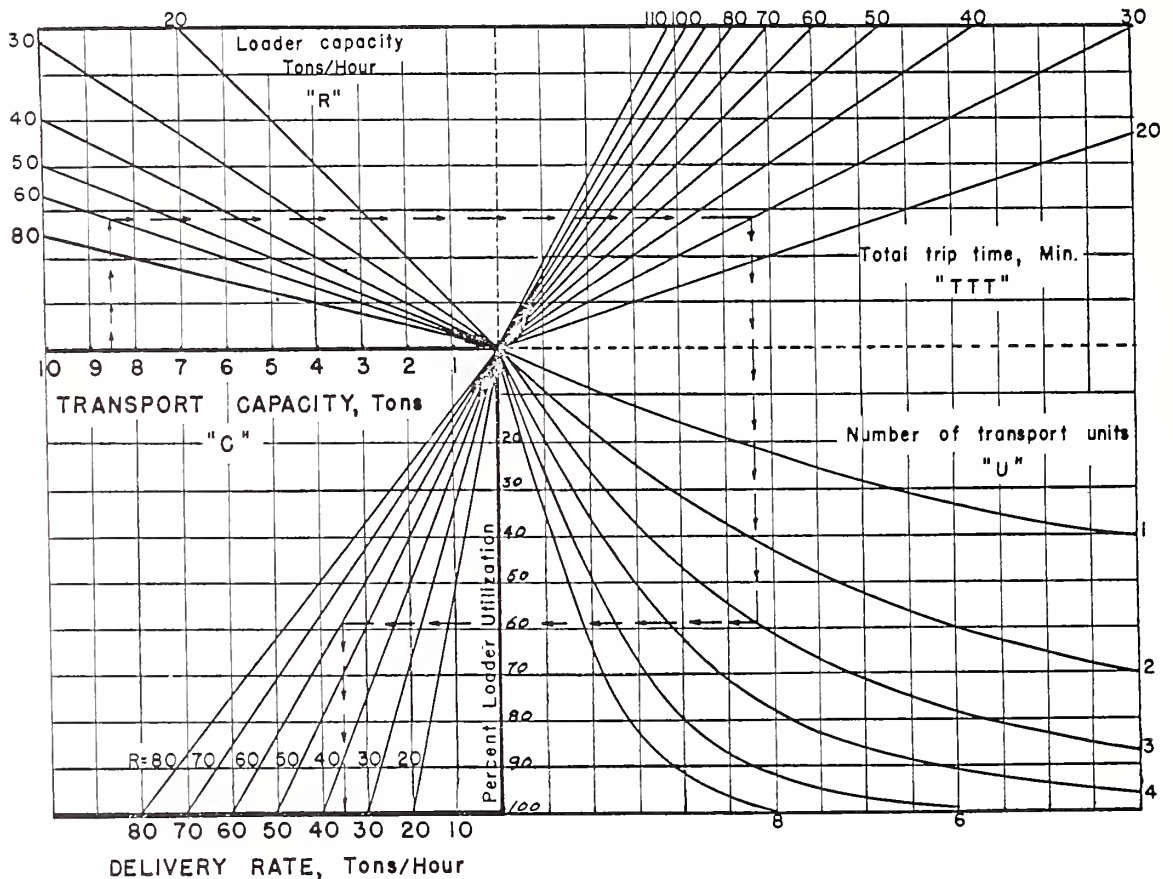


Fig. 5. Nomograph for predicting sugar cane transport system delivery rates.

Verification of the nomograph was made for a single loader transport system during the 1974 harvest season. Table 1 presents observed data for two different transport systems. The predicted delivery rate for System 1, using Fig. 5, was 26.2 tons/hr. and 22.4 tons/hr. for System 2, with an error of less than 5% for both cases. Similar results were obtained when predicted delivery rates were compared with each of the factorial simulations previously discussed.

Table 1. Samples of observed transport system data, 1974 harvest season.

System 1	R = 77 tons/hr.	System 2	R = 78.8 tons/hr.
	C = 8.2 tons		C = 9.7
	TTT = 73 minutes		TTT = 106 minutes
	U = 5.1 units**		U = 4.5 units**
	D _e = 27.4 tons/hr.		D _e = 22.1 tons/hr.

**Weighted time average of number of transport units used

The capability of predicting the delivery rate or determining the size and number of transport vehicles needed for a given transport system is more meaningful if it is associated with economics. Normally economics is a primary basis for selecting a transport system.

The following analysis assumes three expense categories of a loader-transport system; a) labor cost, b) equipment fixed cost, and c) equipment operating cost. Each category and the total system cost are expressed in dollars per ton (\$/ton) of cane delivered to the mill. A mathematical expression for each category is presented using the following nomenclature:

NOMENCLATURE

TC	Transport cost	\$/ton
Lfc	Loader fixed cost	\$/year
Cfc	Cart fixed cost	\$/year
Tfc _i	i th Tractor fixed cost	\$/year
Thu _i	i th Tractor hours of use per year	Hr/year
Shu	Season hours of use	Hr/year
Wlo	Labor cost for loader operator	\$/hour
Wtr	Labor cost for tractor operator	\$/hour
Loc	Loader operating cost	\$/hour
Coc	Cart operating cost	\$/hour
Toc	Tractor operating cost	\$/hour
tp	Round trip distance field to mill	Miles
Nt	Number of transport tractors in use	
Nc	Number of carts in use	
R	Loader rate for given conditions	Tons/hour
S	Average speed of transport units	Miles/hour
Cc	Cart capacity	Tons
Del	Transport system production rate to the mill	Tons/hour
Nco	Number of carts owned	
Nto	Number of tractors owned and reserved for transport system use only during harvest season	

Labor and fixed cost categories fluctuate as the production rate of the system changes. An increase in the delivery rate of a given system would reflect a decrease in the cost per ton for labor and fixed costs categories. Operating costs remain relatively stable regardless of the delivery rate for the system.

$$(\text{Eq. 1}) \quad \text{System labor cost } (\$/\text{ton}) = \frac{Wlo + (Nt)(Wtr)}{Del}$$

$$(Eq. 2) \text{ System fixed cost } (\$/\text{ton}) = \left(\frac{Lfc + (Nco)(Cfc)}{Shu} + \sum_{i=1}^{Nto} \frac{Tfc_i}{Thu_i} \right) \frac{1}{Del}$$

$$(Eq. 3) \text{ System operating cost } (\$/\text{ton}) = \frac{Loc}{R} + \left(Coc + \frac{Nt}{Nc} Toc \right) \frac{tp}{SCc}$$

NOTE: The fixed costs include all carts and tractors devoted to the loading and transporting operation. These costs must be allocated to the system cost even though all units may not be operating all of the time. Combining Equations 1, 2, and 3 into the total system cost:

$$(Eq. 4) \text{ TC } (\$/\text{ton}) = \frac{1}{Del} \left[\frac{Lfc + (Nco)(Cfc)}{Shu} + \sum_{i=1}^{Nto} \frac{Tfc_i}{Thu_i} + Wlo + (N_t)(W_{tr}) \right] \\ + \left[\frac{Loc}{R} + \left(Coc + \frac{Nt}{Nc} Toc \right) \frac{tp}{(S)(Cc)} \right]$$

Example 1:

Assumptions:

- a) All transport tractors were used the same number of hours and had the same fixed and operating expenses
- b) One loader system
- c) Values for equipment were obtained from Campbell (2) and adjusted upward by 30%
- d) Average tractor road speed (S) = 15 mph
- e) Loader capacity (R) = 60 tons/hr
- f) Round trip distance (tp) = 10 miles
- g) Total trip time (TTT) = 50 minutes
- h) One loader system
- i) One transport unit consists of one tractor and two 4 ton carts (Cc), C = 8 tons.

Using the total trip time (TTT) and number of transport units, the delivery rate is obtained from nomograph, Fig. 5. The optimum cost per ton of cane delivered to the mill for this loader-transport system is determined from Equation 4 and the corresponding number of hauling units is selected as shown graphically in Fig. 6.

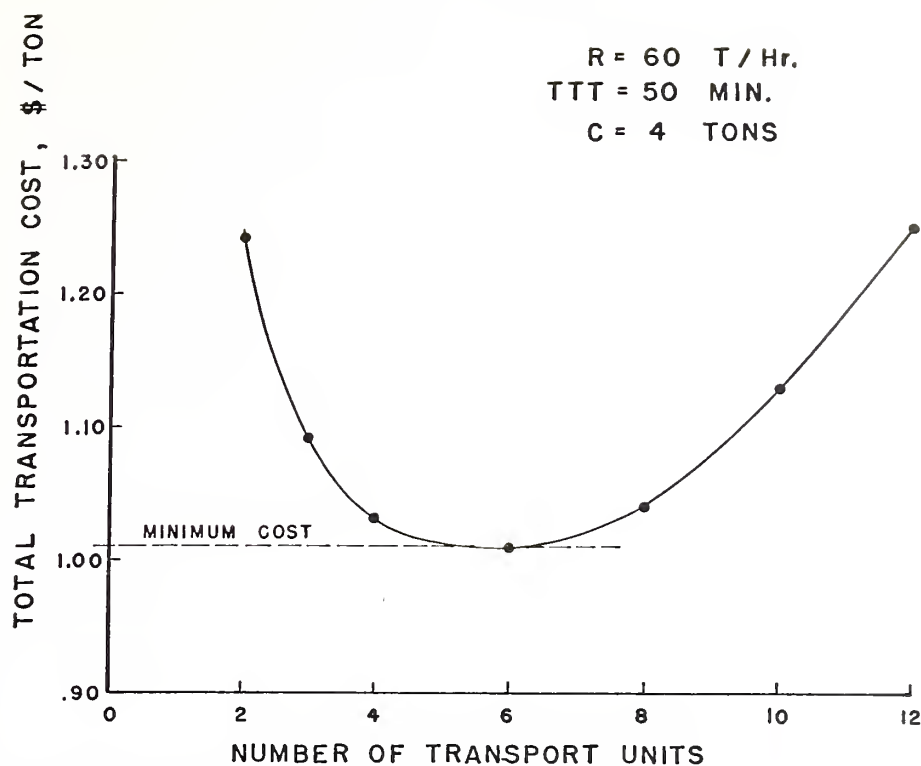


Fig. 6. Graphic illustration of selecting the number of carts for minimum cost a given loader transport system.

Conclusions:

1. The GPSS model presented in this paper simulates actual sugar cane transport systems with reasonable accuracy.
2. Factorial simulation indicates that within the parameter ranges investigated:
 - a) the advantage in delivery rate due to increasing the number of transport units decreases the more units used,
 - b) for any system there is diminishing advantage to delivery rate through increase transport unit capacity,
 - c) total trip time fluctuation has less influence on delivery rate when more transport units are used.
3. The theoretically derived nomograph of Fig. 5 may be used to predict cane delivery rates for single loader systems. Errors are less than 5% for systems with parameter values within the range of those in this paper.
4. Delivery rates for multiple loader systems and greater number of units in the transport system can be obtained using the equations and techniques presented.
5. The optimum cost per ton of cane delivered by a loader-transport system can be determined and used as an aid for selecting and organizing hauling units.

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A POSSIBLE CAUSAL ORGANISM OF RATOON STUNTING DISEASE

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ABSTRACT

A small (0.25 x 1-3 μ m) mesosome containing rod-shaped bacterium has been associated with ratoon stunted L 62-96 sugarcane. Cores from nodes of healthy and diseased cane were placed on top of vacuum tubes. Sterile distilled water was sucked through the cores and the filtrates collected in vacuum tubes. The filtrates were then centrifuged at 14,000 g for 30 minutes. The pellets were resuspended, viewed in the electron microscope, and a bacterium similar to the one reported by Teakle *et al.* (1973) was observed only in preparations from diseased cane. The small number of bacteria observed raises questions concerning their role in ratoon stunting disease. It has not been possible to culture this bacterium.

INTRODUCTION

Ratoon stunting disease (RSD) is a disease of unknown etiology. Others have shown it to be capable of causing 10-30% yield decreases in cane varieties grown in Louisiana. Clearly this is an unacceptable level of disease and, therefore, demanding of research attention. The current practice of heat treating cane to be grown for seed has been somewhat effective in controlling RSD.

The ideal solution to the RSD problem would be the selection of disease resistant varieties which would not require heat treatment. Unfortunately, understanding of the disease is not yet at the level which would allow this approach.

This basic research is concerned with determining the causal organism of RSD. Such information is one prerequisite for selection of disease resistant sugarcane.

The recent literature describes a variety of bacteria as possible causal agents of RSD. One series of reports (2) culminated in assigning *Xanthomonas vasculorum* as the cause of RSD. A Brazilian group implicated *Xanthomonas albilineans* with RSD (4). An Australian group (3) described a small coryneform bacterium which was associated with RSD; while USDA researchers have reported a slightly larger coryneform bacterium (1).

The purpose of this research was to determine whether or not any bacteria were associated with RSD and, if so, whether or not they resembled any that have been previously reported.

MATERIALS AND METHODS

Mature healthy and diseased sugarcane variety L 62-96 from St. Gabriel Experiment Station was brought to the lab and cut into single eye pieces. Longitudinal cores through the nodes were removed with a #14 corkborer. The cores (5-10) were inserted into a vacuum tube and 5 ml of sterile water was sucked through the vascular system. The filtrates were centrifuged at 14,000 g for 30 minutes. Pellets were resuspended in a few drops of sterile water. Particulate matter in these drops was allowed to settle onto a parlodion coated grid. Moisture was removed by adsorption to filtrate paper. Phosphotungstic acid (1.5%) was used as a negative stain. Grids were viewed at 20,000x with an Hitachi HU-11A electron microscope. This experiment was repeated three times.

RESULTS

Similar appearing rod-shaped bacteria were observed in extracts from both healthy and diseased sugarcane. These bacteria did not contain apparent mesosomes when stained with phosphotungstic acid, which indicated a wall structure characteristic of gram-negative bacteria. They were around 1 μ m in diameter and varied from 1 to 10 μ m in length. It is not known if these bacteria were originally present in the sugarcane tissue or were contaminants. The procedures were not performed aseptically and adequate time elapsed to allow bacterial multiplication.

A distinctive rod-shaped bacterium was found only in extracts of sugarcane variety L 62-96 with mature nodal symptoms of RSD. This distinctive bacterium exhibited mesosomes when stained with phosphotungstic acid, which indicated a wall structure characteristic of gram-positive bacteria (Fig. 1A). They are approximately 0.25 μ m in diameter and from 1-3 μ m long. The bacterium often appeared bent (Fig. 1B) or with an enlarged end (Fig. 1C) and must be pleomorphic. Septa characteristic of coryneform bacteria were also observed (Fig. 1D).



Fig. 1. Possible bacterial causal agent of ratoon stunting disease. The bar represents 0.5 μ m.
 A) Mesosome content of bacteria when stained with phosphotungstic acid. B) Bent shape.
 C) Enlarged end. D) Septal formation.

The bacterium was never observed in extracts of healthy appearing L 62-96.

The quick dip technique employed is not quantitative. Nevertheless, counts indicated less than one bacterium per grid hole.

DISCUSSION

These organisms (Fig. 1) appear identical in size, morphology, and mesosome staining, to the coryneform bacterium described by Teakle *et al.* (3), (Personal communication D. S. Teakle). They bear no resemblance to the gram-negative *Xanthomonas* spp. reported by the Puerto Rican (2) or Brazilian scientists (4). The coryneform bacterium as reported by Gillaspie *et al.* (1) was significantly longer (.3-.5 x 5-10 μ m) than I have seen. It is possible that extreme pleomorphism in length exists with this bacterium. We are currently cooperating on efforts to determine if these bacteria are the same or different.

It is not known if the small numbers of the bacterium which can be observed from infected cane are indicative of low titers *in vivo* or poor recovery from infected tissue. If low titers reflect the *in vivo* concentration, how can high dilution end points be obtained in infectivity assays? Is the apparent low titer also responsible for the obscure symptoms of the disease?

Only when the distinctive bacterium is grown in pure culture and Koch's postulates tested can its etiologic role in RSD be determined. Attempts to grow the bacterium have not been successful in this laboratory.

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RIPENING EFFECTS OF GLYPHOSINE: RESULTS OF EXPERIMENTAL
PERMIT TESTING IN LOUISIANA 1973 AND 1974

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ABSTRACT

Glyphosine (CP 41845) or N, N-bis(phosphonomethyl)glycine, the active ingredient in Monsanto's Polaris plant growth regulator, has been shown to be an effective sucrose enhancer and sugarcane ripening agent in Louisiana and many other cane growing areas of the world. Five years of glyphosine research at Louisiana State University and the U.S. Department of Agriculture Sugar Cane Field Station provided information for Monsanto's experimental label program with glyphosine. In 1972, 14 experimental label trials at grower locations on six varieties led to an expanded experimental sales and development program in 1973. This 1973 program involved 69 trials, 22 growers, 14 mills and 737 acres of Louisiana sugarcane. The 1974 program involved 962 acres (data were reported on 730 acres) by 26 growers involved with 62 trials on four varieties, with 11 sugar mills cooperating. In 1973, the average level of sucrose increase from glyphosine treatment in 69 trials was 1.14% with an average gain of 3.09 tons standard cane per acre (TSC/A) or an 11.8% increase in TSC or tons sugar per acre (TSA). In 1974, a season highlighted by droughts (low tonnage), a hurricane (lodging) and high natural sucroses (excellent ripening conditions), glyphosine gave slightly lower effects with an average increase in sucrose of 0.65% with a subsequent gain of 2.46 TSC/A or an overall gain of 6.97% in TSC or TSA for 62 trials. In both seasons, the gains were accomplished with little net effect on tons cane per acre (TCA). The 1973 average treatment yielded 25.31 tons per acre, while the average check yielded 25.44 tons per acre; 1974 average treatment yielded 32.64 tons per acre while the average check yielded 32.06 tons per acre. The 1973 trials indicated that some side benefits might be realized from glyphosine treatment. In 1974, improved burning in 68% of the trials, less trash in 47% of the trials, and improved cutting in 17% of the trials were observed by growers. With full label clearance now in effect (March, 1975), glyphosine will, no doubt, be a useful production tool for Louisiana sugarcane growers.

INTRODUCTION

Glyphosine (CP 41845), N,N-bis(phosphonomethyl)glycine, is the active ingredient in Polaris, Monsanto's sugarcane ripener. Glyphosine, tested for 6 years under a wide range of climatic and cultural conditions, has proved to be an effective sucrose enhancer and cane ripening agent in many parts of the world (1,4). Glyphosine has been particularly effective in hastening maturity at the incline phase of the ripening curve. On recommended varieties under average ripening conditions glyphosine has provided a mean of 10% increase in sugar yield, with a range of 3 to 30% (1). Research has shown the largest gain in sucrose occurs in the upper portion of the treated stalk (3).

Favorable results from 1968 to 1971 led to a temporary experimental permit for glyphosine, which was granted by the EPA on July 24, 1972. This allowed field testing and experimental sales in Hawaii, as well as large scale field trials in Louisiana (2), Florida, and Puerto Rico. The 1972 Louisiana ripener program involved 14 trials with 4 growers and 4 mills, with 6 varieties. A second EPA temporary permit for glyphosine was granted on July 24, 1973 for expanded field testing and experimental sales in Hawaii, Louisiana and Florida. On July 24, 1974, Monsanto Company was granted an extension of the 1973 permit for further field testing and experimental sales in Hawaii, Louisiana, and Florida. The 1973 and 1974 programs in Louisiana are the subjects of discussion here. The 1973 Louisiana program involved 69 trials, 22 growers, 14 mills, and 6 varieties on 737 acres; while the 1974 program involved 730 acres, 26 growers, involved with 62 trials on 4 major varieties with 11 sugar mills, cooperating.

METHODS AND MATERIALS

In both 1973 and 1974, grower contacts and meetings were held in July and August to arrange for experimental testing of glyphosine in Louisiana. All glyphosine was delivered directly to the grower, and the aerial application was supervised by a Monsanto representative. Ripener trials varied in size from 2 to 25 acres in 1973 and 1-1/2 to 52 acres in 1974.

For test purposes, all treatments had an untreated check alongside of similar size containing the same variety of cane grown under the same conditions with the only difference being that of no glyphosine application.

In 1973, 6 major varieties were treated -- L62-96, CP61-37, CP48-103, NCo310, L60-25, and CP52-68. In 1974 only those varieties which had performed best in 1973 were selected for testing -- L62-96, CP61-37, CP48-103, and NCo310. Nearly all applications were made 3 lb ai/acre (3-1/2 lb/acre of product) in 5 to 10 gpa of total spray mixture by airplane 6 weeks before intended harvest (September 1 to October 10).

At harvest time 3 to 10 samples (10 stalks/sample) were randomly taken from the adjacent treated and untreated plot heap rows for processing and analysis at the local sugar mill's sample mill and laboratory where subsequent brix, sucrose, and purity measurements and calculations were made. All these collections were made by Monsanto technical representatives. Stalk weights and counts (per acre) were recorded at harvest. Hand-refractometer-brix measurements were recorded at treatment, 4 weeks after treatment and/or at harvest. Tonnages were calculated from stalk weights and stand counts.

A grower information program was used to encourage growers to apply glyphosine correctly on recommended varieties as well as obtain sample mill data as outlined in 1973. On those fields where it was felt the grower needed assistance or he requested help, Monsanto technical representatives collected samples for brix, sucrose, and purity analysis as in 1973. In as many instances as was possible, stalk weight and lengths as well as counts (per acre) plus hand-refractometer-brix readings were recorded at harvest by these same Monsanto representatives. Tonnages were either calculated from the above information, measured at the scales by the grower, or estimated by the grower based on cart or truck numbers hauled from the area.

Results from both 1973 and 1974 were then transferred from sucrose, purity, and tonnage to Tons Standard Cane (TSC) and Tons Sugar per Acre (TSA) -- Treatment vs. the Untreated Check.

Since sugarcane is a perennial crop and regrows from the previous season's stubble, regrowth counts and measurements of both check and treatment populations were made in 1974 and 1975. This was done to see what long term effects, if any, glyphosine might have on cane growth. Stalk counts and stalk heights were recorded in the spring and at harvest, while stalk weights were taken only at harvest. Observations were also made on any side effects or benefits the ripener might have exhibited in both 1973 or 1974.

RESULTS AND DISCUSSIONS

Ripening conditions for 1973 and 1974 differed sharply. In 1973 September and October rainfall was 170% and 53% above normal, respectively, (see Fig. 1) at Morgan City; whereas, in 1974 September and October rainfall was 40% and 35% below normal at Morgan City. 1974 was extremely dry during this period along with plenty of sunshine and an unusual number of cool night-time temperatures -- ideal ripening conditions! This is best illustrated by comparing the untreated check plot average sucrose and purity values for the two seasons:

	<u>Sucrose</u>	<u>Purity</u>
Untreated check plots - 1973..(69)	12.10	76.99
Untreated check plots - 1974..(62)	12.93	78.80

Thus a 6.8% increase was gained in sucrose from '73 to '74 through better ripening conditions. Therefore, 1974 was hardly an ideal situation for an artificial ripener to work in!

Tables 1 and 2 summarize the results from the glyphosine trials used in 1973 and 1974, respectively. It should be noted that TCA values for both check and treatment in 1973 differed mainly as a result of population differences; therefore, these values were averaged to one TCA. As mentioned earlier, three methods were used to arrive at TCA in 1974 and, therefore, it was felt that these check and treatment values could not be averaged.

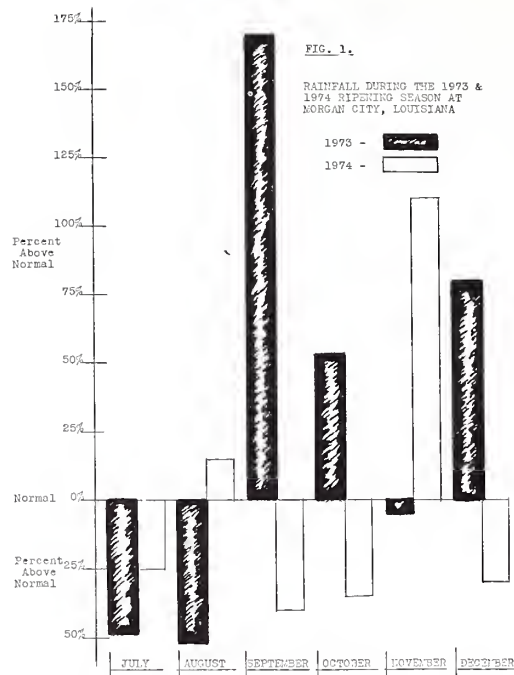


Fig. 1. Rainfall during the 1973 & 1974 ripening season at Morgan City, Louisiana.

Table 1. Results from trials with Polaris in 1973.

Var.	No. Trials	Ave. Date		Sucrose%		Purity		TSC		TSA		Percent Increase
		tr	ht	tr	ck	tr	ck	tr	ck	tr	ck	
L 62-96	29	9/20	45	14.29	12.88	80.81	79.47	30.94	27.67	2.568	2.297	11.8
L 60-25	17	9/24	50	13.73	12.80	79.57	78.28	25.77	23.40	2.139	1.942	10.2
CP 52-68	4	9/21	56	13.44	13.15	78.5	77.59	23.50	22.87	1.951	1.906	2.8
CP 48-103	5	9/25	41	13.61	12.36	80.48	79.15	39.84	35.84	3.306	2.975	11.1
CP 61-37	7	9/23	58	12.66	10.98	78.65	76.26	22.89	19.10	1.900	1.586	19.8
NCo 310	7	9/26	51	11.57	10.36	75.52	73.02	23.25	18.18	1.930	1.509	27.9

Table 2. Results from trials with Polaris in 1974.

Var.	No. Trials	Sucrose%		Purity		TCA		TSC		TSA		Percent Increase
		tr	ck	tr	ck	tr	ck	tr	ck	tr	ck	
L 62-96	26	13.87	13.56	79.99	79.91	29.62	28.30	35.14	32.83	2.915	2.725	6.97
CP 48-103	9	13.63	12.51	79.29	78.28	33.71	34.30	38.40	36.40	3.187	3.021	5.49
CP 61-37	15	13.19	12.52	78.75	78.65	33.77	32.09	37.94	34.57	3.149	2.869	9.76
NCo 310	12	13.63	13.11	79.19	78.37	34.00	33.53	39.46	37.29	3.275	3.095	5.82

The evidence that TCA is not greatly affected by glyphosine can best be shown by looking at stalk weights taken from the heap row and recorded for these two seasons:

	<u>Average stalk weight (lb)</u>	
	<u>1973</u>	<u>1974</u>
Treatment plots	2.54	2.43
Check plots	2.55	2.41
Number of trials	69	33

Note: No significant difference in stalk weight.

In other trials where cart or truck weights were recorded, greater differences were sometimes seen between the treatment and the untreated check. Lost weight tickets, trash, and differences in stand counts confounded this method!

Sucrose, Purity, TSC, and TSA - 1973 was very typical of glyphosine results, showing an 11.8% increase in sugar yield under conditions not ideal for good cane ripening:

	<u>Increase from glyphosine treatment</u>	
	<u>1973</u>	<u>1974</u>
Sucrose	+ 1.06	+ 0.65
Purity	+ 1.56	+ 0.51
TSC	+ 3.10	+ 2.47
Yield increase	+13.94	+ 7.01

The 6.9% increase for 1974 is also typical of what might be expected in a year when conditions are ideal for natural ripening.

Considering the number of trials, the late season variety CP 61-37 was one of the best responders to glyphosine application. It appears to have responded quite well under the varied conditions of these 2 seasons, averaging a 14.8% yield increase.

<u>Variety</u>	<u>No. trials</u>	<u>Percent yield increase</u>		<u>Ave.</u>
		<u>1973</u>	<u>1974</u>	
L 62-96	55	11.82	6.97	9.40
CP 61-37	22	19.84	9.76	14.80
CP 48-103	14	11.10	5.49	8.30
NCo 310	19	27.90	5.82	16.86
L 60-25	17	10.20	----	----
CP 52-68	4	2.80	----	----

Although the average response of L 60-25 was an increase of 10.2% it had responded so irregularly in 1973 that it was not recommended for trial use in 1974. Similarly, CP 52-68 was eliminated from the trial schedule. If these two inconsistent varieties are not considered in the 1973 results, we find the average yield increase to be 16.75% or average gain of +3.87 TSC/acre. During this entire 3-year experimental period, the popular variety L 62-96 has been tested the most for glyphosine response (59 trials). Although an early variety, L 62-96 has responded well and most consistently in these trials. Variety NCo 310 was somewhat of a disappointment in 1974 after its dramatic showing in 1973 (27.9% yield increase). It might be noted that the varietal responses by increase in sucrose were quite outstanding from glyphosine treatment in 1973.

Hand refractometer brix readings from composite punch juice samples were made in 69 trials an average of 34 days after treatment on standing cane in 1973 at the middle and upper internodes. In 1974, similar readings were made on heap row cane at harvest on lower, middle, and upper internodes in 34 trials. The following data represent the average increase in brix over the check from glyphosine:

	<u>1973</u>	<u>1974</u>
Upper stalk	3.27	2.43
Middle stalk	1.27	1.74
Lower stalk	----	1.37

As has been shown by other research (3) the brix and sucrose increase from glyphosine occurs largely in the upper portions of the treated stalk. The following data show the increase from glyphosine in brix by variety:

<u>Variety</u>	<u>1973</u>			<u>1974</u>			
	<u>Upper</u>	<u>Middle</u>	<u>Average</u>	<u>Upper</u>	<u>Middle</u>	<u>Lower</u>	<u>Average</u>
L 62-96	4.76	1.31	3.04	2.05	1.94	1.96	1.98
CP 61-37	2.11	0.35	1.23	2.47	1.43	1.16	1.69
CP 48-103	3.10	1.36	2.23	3.70	2.29	1.48	2.49
NCo 310	2.33	1.48	1.91	1.50	1.27	0.90	1.22
L 60-25	4.42	1.73	3.08	----	----	----	----
CP 52-68	2.89	1.42	2.16	----	----	----	----

In 1974, the four varieties tested generally responded better in the middle portion of the stalk than in 1973; whereas variety L 62-96 and NCo 310 did not respond as well in the upper stalk portion in 1974. It appears that in a good natural ripening year, changes in the upper portion of the stalk may not occur quite as drastically when glyphosine is applied and are therefore less of a factor in the total increase in sucrose.

All varieties showed various degrees of leaf desiccation in both years of testing as shown in the following data:

<u>Variety</u>	<u>Estimated leaf desiccation</u>	
	<u>due to glyphosine (%)</u>	
	<u>1973</u>	<u>1974</u>
L 62-96	10	10
CP 61-37	25	20
CP 48-103	10	20
NCo 310	Less than 1	Less than 5
L 60-25	25	--
CP 52-68	25	--

One of the side benefits from the physiognomic effect of desiccation has appeared to be better burns resulting in less trash at the scales. Also, in 1973 there was a trend for glyphosine to reduce late season lodging when applied to cane not yet lodged (15 to 20 tests). It is thought that this may have occurred for one or two reasons -- that is a result of the lighter upper leaves in those varieties that desiccate well and/or the "rubbery" characteristic that the cane stalk takes on after treatment with glyphosine. In 1973 some growers felt the cane cut easier because of this rubbery characteristic. To more definitely document any side benefits from glyphosine in 1974 growers were questioned as part of the grower information program. They said:

68% of the trials burned better, while 32% burned as well when treated;
 47% of the trials had less trash, while 38% had equal trash and 15% had more trash;
 17% of the trials appeared to cut better (less breakage), and 83% appeared to cut the same.

Since approximately 80% of the fields were lodged at the time of treatment, very little lodging control could be gained from the use of glyphosine in 1974.

Stalk counts from 44 trials treated in 1973 were taken at harvest in the fall of 1973 and at harvest in the fall of 1974. The data for 6 varieties were as follows in percent change from 1973 to 1974:

<u>Variety</u>	<u>No. trials</u>	<u>Treated</u>	<u>Check</u>
L 62-96	25	-17.1	-20.9
L 60-25	6	-9.7	-19.4
NCo 310	4	+1.4	-22.4
CP 61-37	4	-5.4	-17.6
CP 48-103	2	+13.7	+30.3
CP 52-68	3	+19.9	-0.9
<u>Ave.</u>		+0.5	-9.3

Both in 1973 and 1974 a reduction in regrowth emergence was observed in most treated plots immediately after harvest. But as the foregoing data show, this situation was drastically reversed the following year. Perhaps this slow post harvest regeneration brought on by glyphosine protects treated stubble from winter kill in Louisiana conditions.

Regrowth height measurements were taken in the spring of 1974 when the average shoot height was 22.0 inches above the ground. There was an average reduction of -3.6% in shoot height in the treated plots when compared to the adjacent untreated checks. However, when measurements were taken on these locations at harvest, the trend seemed to be in the other direction:

<u>Average stalk length (in.)</u>	
1973 Treated	71.5
1973 Untreated	70.2

The effects at 1974 harvest on stalk weight were studied in 13 trials treated in 1973 and not retreated in 1974:

<u>Treatment (lb)</u>			<u>Check (lb)</u>		
1973	1974	net	1973	1974	net
<u>stalk wt</u>	<u>stalk wt</u>	<u>change</u>	<u>stalk wt</u>	<u>stalk wt</u>	<u>change</u>
2.78	2.44	-0.34	2.81	2.35	-0.46

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RESPONSE OF SUGARCANE TO DELAYED COVERING
AND SEEDPIECE SIZE

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ABSTRACT

Yield of cane was compared from two-, four-, and eight-bud seedpieces of C. P. 36-111 sugarcane stored in open furrows at intervals of zero, four, seven, 14, and 21 days before covering with soil during October and November 1965-67 at Meridian, Miss. Yields of cane from seedpieces stored in open furrows for up to 7 days were not significantly different from those covered immediately after planting. However, yield of cane was significantly reduced after seedpieces were exposed 14 or 21 days. The yield of cane from four- and eight-bud seedpieces was similar to and significantly higher than that from two-bud seedpieces. Plant emergence in the spring decreased significantly as the size of seedpiece increased.

SUGARCANE TECHNOLOGY
ASSOCIATE OF SCIENCE DEGREE PROGRAM
AT NICHOLLS STATE UNIVERSITY

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ABSTRACT

Nicholls State University, in Thibodaux, Louisiana, is planning to offer an Associate of Science Degree Program in Sugarcane Technology. This two-year curriculum, offered in the University's Department of Agriculture, consists of two separate and distinct options: Processing and Production. The student will select courses in one of these areas to prepare for employment in the factory or in field (agricultural) operations.

The goal of the program is to develop qualified mid-management level personnel for the sugar industry. The program aims at providing students with an understanding of the methods, skills, materials and processes commonly used in the sugarcane industry. Upon employment, a brief period of orientation to particular duties in the employee's organization, together with continued on-the-job study will permit students to advance to higher levels of productivity and increased responsibilities.

Students will obtain a sound understanding of the application of basic biological and physical sciences as they relate to processes and activities in the sugarcane industry. The program will allow for a period of actual work experience or internship which is carefully planned, closely supervised and evaluated for a better understanding of tasks and duties involved in the field.

The curriculum, developed by an advisory committee of university personnel and sugar industry representatives, is also designed to permit the transferability of course credits to a baccalaureate curriculum and does not preclude a student's continuation toward such an objective.

INTRODUCTION

The Louisiana sugarcane industry is in need of trained personnel to operate the sugar factories, refineries, and sugarcane farms. There are approximately 40 sugarcane factories in Louisiana involved in processing the state's tremendous sugarcane crop. These mills employ approximately 4,000 workers during each processing season. Approximately 15,000 farm workers are involved in the actual production of the cane on approximately 355,000 acres of land.

The future of the sugar industry in Louisiana, Florida, Texas, and other sugar producing areas looks excellent. The growing of sugarcane is better adapted to these areas than are other farm enterprises. Farms will continue to increase in size and in complexity. Factories will become more sophisticated and efficient. Competent, well trained personnel will be needed to operate these farms and factories.

Nicholls State University, in Thibodaux, is now offering an associate of science degree program in Sugarcane Technology. This two-year curriculum offered in the university's Department of Agriculture consists of two separate and distinct options: processing and production. The student will select courses in one of these areas to prepare for employment in the factory or field (agricultural) operations. Students completing the processing option of this curriculum would be prepared to fill technical level positions in the operations of sugar factories and refineries. Those completing the production option would qualify for employment as supervisory level personnel in sugarcane farming operations.

The overall goal of the program is to develop qualified mid-management level personnel for the sugar industry. The specific student-oriented objectives can be stated as follows:

- a. To provide students with an understanding of the methods, skills, materials, and processes commonly used in the sugarcane industry. Upon employment, a brief period of orientation to particular duties in the employer's organization, together with continued on-the-job study should permit students to advance to higher levels of self motivation, productivity, increased responsibility and mid-management capabilities.

- b. To provide students with some understanding of social and economic factors so that they have a better awareness of our social structure.
- c. To provide students with basic proficiency in mathematics and communication skills.
- d. To give students an understanding of the application of basic biological and physical sciences as they relate to processes and activities in the sugar industry.
- e. To allow for a period of time for work experience which is carefully planned, closely supervised, and evaluated for a better understanding of tasks and duties involved in the field.
- f. To permit the transferability of course credits to a baccalaureate curriculum so that this program does not preclude a student's continuation toward such an objective.

Students will receive formal training in all areas essential to their selected field of employment. In addition, actual field experience will be obtained in those courses entitled internship or special problems. In the internship courses, students will receive work experience while being employed and earn college credits at the same time. The special problems courses are intended to permit the student to observe factory or field operations in order to better understand practices employed in the sugarcane industry.

The curriculum (each option) is designed to be completed in two years. Some students may choose to stay out for work during some semesters and may complete the program over a longer period of time.

Listed below is a copy of the curriculum as it will appear in the new 1976 Nicholls State University Catalog. Students will obtain a sound understanding of the application of basic biological and physical sciences as they relate to processes and activities in the sugarcane industry.

The curriculum, developed by an advisory committee of university personnel and sugar industry representatives, is also designed to permit the transferability of course credits to a baccalaureate curriculum.

Sugarcane Technology
Associate of Science Degree
(Options in Processing and Production)

YEAR ONE

First Semester

Core Courses:

Agricultural Science 101 (Orientation to the Sugarcane Industry).....	1
Chemistry 115 (315) Raw Sugar Chemical Analysis.....	2
English 101 (Basic Composition).....	3
Mathematics 101 (Algebra).....	3
	<u>9</u>

Processing Option:

Core Courses.....	9
Engineering Science 101 (Graphics).....	2
Physics 101, 103 (--Mechanics, heat and sound).....	4
	<u>15</u>

Production Option:

Core Courses.....	9
Biology 101, 103 (General Plant Biology).....	4
Plant Science 121, 122 (Introduction--).....	4
	<u>17</u>

Second Semester

Core Courses:

Accounting 219 (Survey Course).....	3
English 102 (Basic Composition).....	3

Processing Option:

Core Courses.....	6
Electrical Technology 230 (Circuits).....	3
Engineering Science 201 (Descriptive Geometry).....	2
Mathematics 102 (Trigonometry).....	3
	<u>14</u>

Production Option:

Core Courses.....	6
Agricultural Science 201 (Special Problems).....	2
Agricultural Science 250 (Farm Machinery).....	3
Mathematics 105 (Business Math).....	3
	<u>14</u>

Summer

Core Courses:	
Economics 255 (Economic Principles)...	3
Plant Science 308 (Sugarcane Production).....	4
	<u>7</u>
Processing Option:	
Core Courses.....	7
Agricultural Science 201 (Special Problems) - Optional.....	2
Chemistry 320 (Chief Chemists Records and Calculations).....	3
	<u>10-12</u>
Production Option:	
Core Courses.....	7
Agricultural Science 202 (Special Problems).....	2
	<u>9</u>

YEAR TWO

First Semester

Core Courses:	
Agricultural Science 310, 311 and 312 (Agricultural Internship).....	12
	<u>12</u>
Processing Option:	
Core Courses.....	12
Chemistry 325 (Principles and Processes of Sugar Boiling).....	3
	<u>15</u>
Production Option:	
Core Courses.....	12
	<u>12</u>

Second Semester

Core Courses:	
English 368 (Technical Writing) or Management 310 (Business Communications).....	3
Management 300 (Supervisory Management).....	3
	<u>6</u>
Processing Option:	
Core Courses.....	6
Approved Elective.....	3
Electrical Engineering Techno- logy 360 (Electric Machinery).....	3
Mechanical Engineering Techno- logy 310 (Thermodynamics).....	3
	<u>15</u>
Production Option:	
Core Courses.....	6
Agricultural Science 301 (Farm Management).....	3
Plant Science 351 (Soils).....	4
Plant Science 408, 409 (Sugarcane Pests).....	4
	<u>17</u>

Total Semester Hours:
Processing Option....69
Production Option....69

DETERIORATION LOSSES IN FLORIDA SUGARCANE

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ABSTRACT

The deterioration rates of burned and unburned samples of five Florida sugarcane varieties have been compared. Bases for comparison were calculated tons 96° sugar per acre, losses in juice purity, and increases in invert sugar and polysaccharides. Varietal differences in rate of deterioration were indicated, and overall losses of at least 5.3% of total sugars in cane were seen between one and four days postharvest.

INTRODUCTION

Postharvest deterioration rates have been investigated in several parts of the world and found to be highly variable (1). In addition, the increasing dependence upon mechanical harvesting makes this subject even more timely, since a number of studies have indicated that mechanical harvesting results in increased deterioration losses (2,3). In order to illustrate the magnitude of the losses incurred, I have reproduced some data obtained by Clewiston factory personnel on machine-harvested cane (Table 1).

Table 1. Deterioration losses in machine-harvested cane. Variety - CL 54-378. Burned - January 24, 1975. Loaded - January 25, 1975.

Sample	Juice Analysis (1/25/75)			Yield 96° sugar
	Brix(°)	Sucrose(%)	Purity(%)	
1	17.46	14.67	84.02	10.42
2	18.49	15.34	82.96	11.00
3	18.39	15.28	83.09	10.95
Mean	18.11	15.10	83.36	10.79

Sample	Juice Analysis (1/27/75)			Yield 96° sugar
	Brix(°)	Sucrose(%)	Purity(%)	
1	17.87	13.60	76.11	9.24
2	17.29	12.73	73.63	8.46
3	17.37	12.61	72.60	8.16
Mean	17.51	12.98	74.11	8.62

Both groups of samples were from the same field, were burned and loaded at the same time, and were of the same variety. The only difference between the two groups is the delay between loading and milling. The purity decreased by 11.1% and the calculated sugar yield decreased by 20.1%!

Several factors account for sugar losses in harvested cane. In the field, loss of cane weight and sucrose inversion occur to produce easily-assessed direct sugar losses. In addition, the accompanying increases in fiber percent cane and juice levels of invert sugar and polysaccharides make the sucrose remaining in the cane more difficult to extract and crystallize in the factory. To adequately treat the subject of cane deterioration, both types of losses must be considered. It is well known that cane deterioration causes several adverse effects upon milling operations, and theoretical calculations of available sugar per ton of cane do not really take these factors into account.

Since results in the literature are quite variable depending upon weather conditions, varieties used, etc., it was deemed desirable to obtain data on the deterioration rates of Florida varieties under Florida conditions.

EXPERIMENTAL PROCEDURE

Studies employing unburned cane were conducted at the end of January, 1975, while the studies on burned cane were conducted at the beginning of March, 1975. All five varieties used were mature first stubble cane last cut in early February, 1974, and all were located in the same field to eliminate any soil-induced compositional differences. Soil composition was 86% organic, 14% non-silicate minerals, and 0% sand (9).

For each of the two phases of these studies, 128 sound, mature stalks of each of the varieties CL 41-223, CL 54-312, CL 54-336, CL 54-405, and CL 61-205 were cut, topped at the first green joint, stripped of all trash, and tied into numbered bundles containing 8 stalks each. Bundles were promptly returned to the laboratory, weighed, and stacked loosely on a thin layer of trash in an open field. At selected intervals, four bundles of each variety were withdrawn from the stacks at random for analysis. One bundle was used to determine fiber % cane (10), while the other three were reweighed and then crushed in the laboratory's three-roller cane mill. The three juice samples so obtained were analyzed for refractometer brix and polarization after lead subacetate clarification. A composite sample consisting of equal volumes of each of the three juices was analyzed for invert sugars (11) and gums (12).

For calculation of available sugar on a tons per acre basis, a figure of 40 tons cane per acre was assumed for all varieties at time of harvest. Subsequent weighings were used to revise this figure downward at each sampling date. Theoretical sugar yields were calculated according to a formula (Equation 1) based on the work of Arceneaux (13)

$$\% \text{ yield } 96^{\circ} \text{ sugar} = Sx - By \quad (\text{Eq. 1})$$

and modified by Bourne (14), where S is percent sucrose in crusher juice and B is brix of crusher juice. Sucrose and brix reduction factors (x and y, respectively) required by this treatment were based on the average of the past five years' mill performance data of United States Sugar Corporation's Clewiston factory and were corrected for changes in fiber percent cane determined at each analysis.

RESULTS AND DISCUSSION

Five different Florida sugarcane varieties (CL 41-223, CL 54-312, CL 54-336, CL 54-405, CL 61-205) were compared in these studies, and three different parameters were used to determine relative rates of postharvest deterioration. In addition, the effects of preharvest burning as practiced in Florida were studied by comparing burned and unburned samples of the same sugarcanes.

The first parameter used was calculated tons 96° sugar per acre based on individual values for brix, polarization, fiber percent cane, and cane weight. This method is quite useful, but is susceptible to criticism on at least two grounds. First, the presence of invert sugars and polysaccharides in deteriorated cane may caused errors in juice polarization (4,5). Second, the crystallizability of the sugar present in deteriorated cane is expected to be reduced due to the increased viscosity of process liquors and the concentrated inorganic salts in the juice of dried-out cane (6). A second criterion for judging degree of deterioration is purity drop of the juice. This gives an idea of sucrose losses and also of losses in processing quality. The final approach examined involved direct analyses for invert sugars and polysaccharides, both of which are widely-used indicators of cane quality (7,8). Due to the careful selection of only sound mature stalks and to the rather mild weather prevailing during the course of these studies, this latter approach was ineffective, i.e., neither invert sugar nor polysaccharides was produced in quantity. One point worth mentioning, however, is the broad range of percent invert sugar levels seen at nine days after harvest in samples of burned cane (Fig. 1). All five varieties yielded juice essentially free of invert sugar at time of harvest. However, at nine days postharvest, CL 54-312 cane yielded juice containing 0.56% invert sugar, while the juice of CL 61-205 cane contained 1.04%, or approximately twice as much. The remaining three varieties were found to be intermediate between these extremes. These data thus indicate that, under the less favorable conditions expected in the field where the cane is exposed to reservoirs of infection, significantly different levels of invert sugar may be expected to develop during the delay between cutting and milling.

Turning to the more illuminating and productive lines of investigation concerning calculated tons 96° sugar per acre and juice purity drops, it may be noted that the varietal influence indicated by the just-discussed invert sugar data is more evident here (Fig. 2).

Sugar losses at four days postharvest range from zero to a very substantial 9.45% of the sugar present on the day following cutting. Similarly, juice purity drops range from 1.9% to 4.0%. It should be noted that the varietal influence is decidedly less pronounced at longer storage times. Thus, at nine days after harvest, sugar losses were all in the range 14.3-19.1%, and juice purity losses were all 6.0-7.8%.

The average sugar losses and purity drops for the five varieties sampled were, respectively, 0.25 tons 96° sugar per acre and 2.59 points purity (Table 2). The 0.25 tons of sugar is 5.3% of the total sugar available in the cane at one day after cutting. This figure is in good agreement with the figure of 5% recently reported by Gascho et al. (2) for whole stalk burned cane stored three days under Florida conditions.

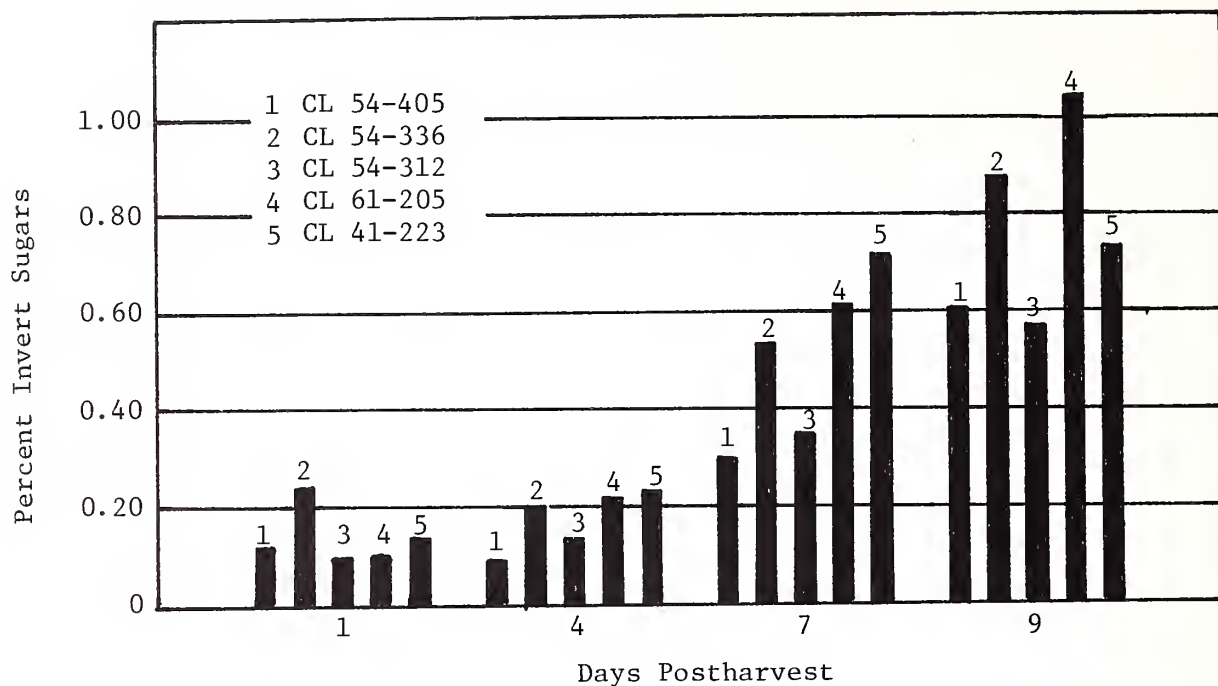


Fig. 1. Deterioration of five Florida varieties as shown by juice levels of invert sugars.

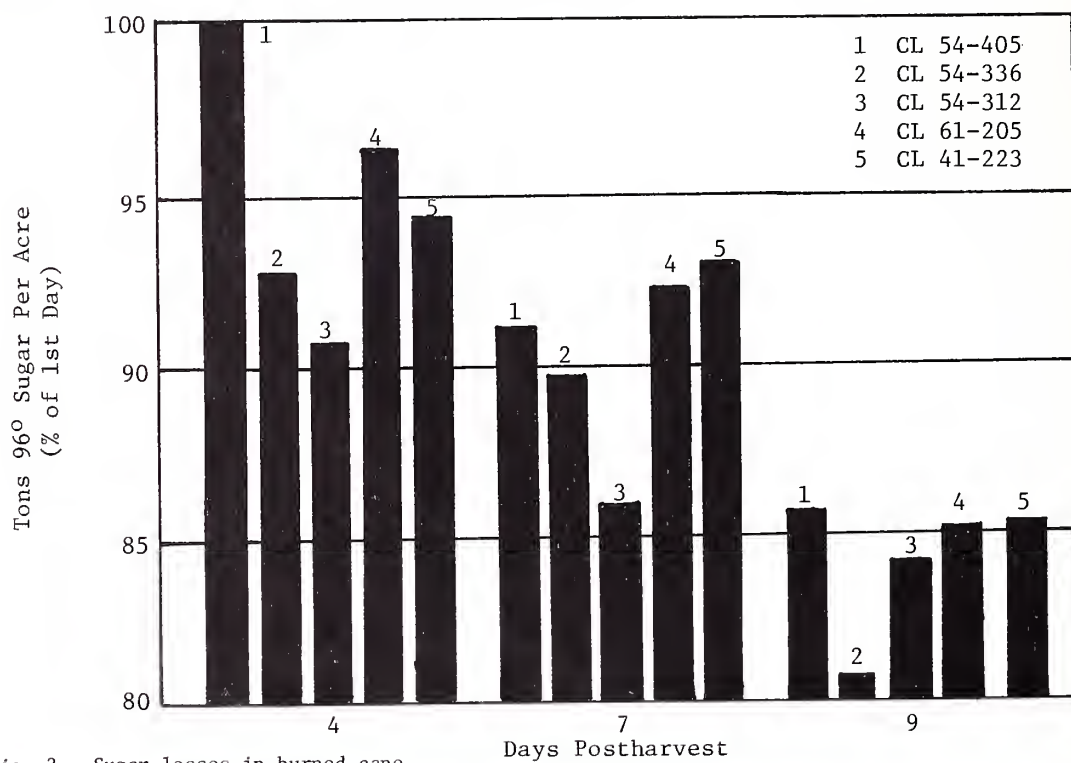


Fig. 2. Sugar losses in burned cane.

Table 2. Deterioration of five burned Florida varieties as judged by theoretical tons 96° sugar per acre (TSA) and juice purity (JP).

Variety	Days postharvest							
	1		4		7		9	
	TSA	JP	TSA	JP	TSA	JP	TSA	JP
CL 54-405	4.88	93.43	4.91	91.18	4.44	89.72	4.18	87.87
CL 54-336	4.76	94.39	4.42	90.64	4.26	88.94	3.85	87.76
CL 54-312	4.76	93.86	4.32	91.71	4.05	88.57	4.01	88.08
CL 61-205	5.08	94.20	4.88	91.23	4.68	89.39	4.36	86.87
CL 41-223	4.65	92.80	4.38	91.01	4.32	88.22	3.97	86.01
Mean	4.83	93.74	4.58	91.15	4.35	88.97	4.07	78.32
Mean loss	--	--	0.25	2.59	0.48	4.77	0.76	6.42

These figures increase to 9.9% (0.48 ton) and 15.7% (0.76 ton) at seven and nine days post-harvest, respectively. Juice purity drops parallel sugar losses, increasing to 4.77 points at seven days and to 6.42 points at nine days. It is thus evident that appreciable quantities of sugar are lost quickly, while the sugar left in the cane becomes harder to extract efficiently.

In contrast to the just-discussed data on burned cane, the corresponding data on unburned cane of the same five varieties indicate deterioration to be less severe (Table 3). At seven days after harvest, for example, the calculated losses in tons 96° sugar per acre and juice purity are 50% less than with burned cane of the same varieties and very nearly the same age. Though the burned cane was approximately four weeks older than the unburned cane, results in the literature (8) indicate that age of cane within rather broad limits is not a factor in determining deterioration rates. Prevailing temperatures, however, are definitely quite important. Table 4 shows pertinent weather data for the week ending January 27 when the unburned cane experiments were carried out and for the week ending March 10 when the burned cane experiments were done. It is seen that the burned cane actually was stored under more favorable conditions than was the unburned cane, yet the latter suffered much less severe deterioration losses. It may be concluded that preharvest burning accelerates the deterioration process markedly under Florida conditions.

Table 3. The effects of preharvest burning on the rates of cane deterioration.

Postharvest	Δ JP (%)		Δ TSA (%)	
	Burned	Unburned	Burned	Unburned
4	2.74	1.88	5.31	4.30
7	5.09	3.45	9.88	6.41

Table 4. Temperature and rainfall data for week of January 20-27 and March 3-10, 1975, Clewiston, Florida.

Week Ending	Temperatures (°F)			Rainfall (Inches)
	Max.	Min.	Average	
January 27	84	58	70.3	0.53
March 10	84	41	63.1	0.46

SUMMARY AND CONCLUSIONS

Studies on burned samples of five Florida sugarcane varieties have shown that minimum losses of at least 5.3% of the available sugar content and 2.59 points juice purity occur during the period between one and four days after cutting. Due to the cool weather and favorable storage conditions used, these figures are in all probability quite optimistic. Significant varietal differences in rate of postharvest deterioration are indicated by these data. Finally, comparison between burned and unburned samples of the same varieties indicated that preharvest burning markedly accelerates the deterioration process. In light of these results, further investigation into this problem is planned to evaluate the potential value of screening varieties for deterioration resistance. As more high-sucrose, early-maturing varieties become available, it may very well be possible to apply additional selection criteria such as deterioration resistance to maximize sugar production. This may also help to soften the blow of the changeover to mechanical harvesting methods which seem to increase deterioration losses. Finally, it is felt that the inclusion of as many direct evaluations of processing quality as possible (such as deterioration resistance) into selection procedures is desirable to maximize sugar yields.

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AN AUTOMATED METHOD FOR ANALYZING LARGE
NUMBERS OF SUGARCANE JUICE SAMPLES^{1/}

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ABSTRACT

An electronic refractometer and polarimeter to measure brix and pol, respectively, are interfaced with a programmed calculator and output writer. The printout gives sample number, variety, plot number, observed brix, temperature, pol, corrected brix, apparent sucrose, apparent purity, varietal correction factor (VCF), and estimated recoverable 96 pol sugar per ton of cane (sugar/ton). Only temperature and VCF are keyed into the calculator manually, and only the variety and plot number are typed manually. Information from the refractometer and polarimeter is channeled through the electronic interface; calculated results are typed automatically. The present calculator program includes the factors needed to convert observed brix to corrected brix and pol to sucrose, and to calculate estimated sugar/ton. With automation of juice analysis 2 technicians can process 250 samples per 8 hour day. Automation increased efficiency of technicians, minimized chance of error in observation and transcription of data, and provides legible, tabular data that require minimum additional calculations.

Knowledge of the composition of cane juice, especially brix, sucrose, and purity (by calculation), is essential for effective control and improvement of sugarcane varieties (interspecific hybrids of the genus *Saccharum*). At the U. S. Sugarcane Field Laboratory, Houma, Louisiana, 6-10,000 samples of sugarcane juice are analyzed annually in the mill laboratory. Prior to 1967 all samples were handled in the traditional manner: Hydrometer (spindle) to measure degrees brix and a suitable optical instrument to measure the rotation of polarized light for determination of apparent sucrose (3). Since 1967 the manual polarimeter has been replaced by an automatic polarimeter and the hydrometer by an automatic refractometer. Transfer and calculation of results have been upgraded by the addition of an electronic interface and a programable calculator and output writer.

When the brix hydrometer is used the juice sample should stand in a cylinder until all air bubbles have risen to the surface. A vacuum can be used to help remove air. The hydrometer is then lowered into the sample for 2-3 mm above the point where it comes to rest. Sufficient time must be allowed for the spindle to reach the same temperature as the sample. The spindle is read at the level of the liquid, not at the meniscus. Then, since most spindles are generally calibrated to read 0° in distilled water at 20C, the temperature of the solution must be read on a thermometer (either enclosed in the spindle or by a separate thermometer floated in the liquid) so that the correction for temperature can be applied. The total time required to measure brix in this manner may exceed 30 minutes.

Polarization of lead-preserved juice samples is relatively simple. A portion (usually 100-150 ml) of the juice after brixing is placed in a bottle, 3 or 4 grams of dry lead sub-acetate is added for each 100 ml of juice, and after thorough mixing and filtration, the filtrate is polarized in a 200 mm tube. Of course, incremental additions of lead subacetate would be preferential in avoiding "overleading" errors. However, this source of error is not frequently encountered in handling clean, undeteriorated cane samples. Apparent sucrose is calculated from Schmitz's table for undiluted solutions.

Standardized or calibrated brix hydrometers with correction factors supplied for several reference densities, cost \$20-\$40. On the other hand, conventional polariscopes or saccharimeters with manual visual adjustment for industrial use cost between \$3-8,000.

Spindle brix is not a true measure of soluble solids in a solution. By definition brix is the percentage by weight of sucrose in a pure sugar solution. However, it is customary to consider brix as the percentage of total dissolved solids in a liquid. Consequently, the brix of an impure sugar solution is invariably higher by spindle than by drying since non-sugar solids generally present are of higher density than the sugars. A further complication is caused by contraction on dilution. Therefore, brix by spindle is only a close approximation of the percentage of soluble solids and is subject to error depending on the non-sugars present in the juice. Errors

^{1/}Research at this laboratory is in cooperation with the Louisiana Agricultural Experiment Station.

are also frequently introduced if the spindle touches the side of the cylinder and rests on settled juice insolubles - soil, bagacillo particles, etc. However, this is a problem more frequently encountered in the factory than in the sample mill extractions due to trashy cane and disintegration of stalks before milling under factory conditions.

With the standard type polariscopes, possible sources of errors are: adjusting the field and reading the vernier, the position and intensity of the light source, adjustment of the scale, condition of the polarimeter tube, and preparation and temperature of the sample. Errors range from 0.1° pol to as much as 10.0° pol. Further, human error can be introduced into both the brix and pol readings by carelessness and eye fatigue.

This paper describes the method used to automate the analyses of juice samples at the Houma Laboratory. As many as 250 samples can be processed during an 8-hour day. Also, human error is held to a minimum. In this method brix and pol are measured by an electronic refractometer and polarimeter, respectively, interfaced with a programmed calculator and output writer. This system minimized human error of measurement, observations, and transcription of data and increased efficiency of technicians and provides legible, tabular data that require minimum additional calculations.

INSTRUMENTATION

In 1967 an electronic, self-balancing, photoelectric polarimeter, Bendix Model 1174-01, with digital readout and printer was installed at the Houma Laboratory. This instrument is calibrated to read from 0-100° ISS for positive rotation in a 2 mm flo-thru cell, and is accurate to 0.02% throughout its entire range.

Raw juice samples have to be clarified with lead sub-acetate to remove particulate matter; however, the Bendix polarimeter can be used with cloudy or hazy solutions due to the short path length of the sample cell. The short path length of a Bendix Model 700 automatic polarimeter, used in field work in Australia, was cited as a distinct advantage over two other instruments tested (1); the disadvantages listed were the relatively slow speed of operation and unreliability of electronic circuitry.

Calibration is necessary but once annually; however, performance is checked daily with a manually adjusted polarimeter. Zero drift over an extended period is minimal.

To further automate the analyses of samples an Electron Machine Corporation, Model SSR-72, critical angle automatic refractometer with digital readout was purchased. This instrument replaces the spindle brix. Within its limitations, i.e., solutions containing only soluble solids and a small proportion of non-sugars, the refractometer accurately indicates solids content (brix) usually in close approximation to values obtained by drying (3). No attempts have been made to compare data based on either spindle or refractometer over a wide range of soil types. It is possible that where salts in juice vary significantly the differences in soluble solids might fluctuate to a greater degree than expected.

In the SSR-72 a rotating helical scanner is used to sweep a beam of light continuously through a series of angles at the interface of a sapphire prism and the juice sample. This instrument is calibrated to read brix on a scale of 5-25% with an accuracy of $\pm 0.5\%$ of span.

Raw juice samples of 30-50 ml are poured directly through a quick-release sample cell. Visual and electrical outputs are automatically temperature compensated to 20C within an operating temperature range of 10-25C. Sixty measurements a second are taken and a change in the sample is detected by the solar cell within 16 milliseconds.

Particulate matter was removed from the samples by filtering the raw juice through a double layer of cheesecloth before the sample was introduced into the refractometer. Oil droplets in some samples caused erratic brix readings; however, this problem was corrected by changing the method of lubricating the sample mill so that the oil did not overflow into the juice. The most serious problem is the continuing need to calibrate the instrument for each set of 10 samples analyzed. The manufacturer attributes that problem to a faulty circuit and is trying to correct the problem.

For the complete automation of juice analyses, a programable calculator, Wang Model 700C, was installed; it has program capacity of 960 steps and 120 storage registers. Manual entry of data from the polarimeter and refractometer to the calculator and the accompanying risk of error were eliminated by installation of an electronic interface, Adams-Smith Model 100-1. The interface accepts and stores 4-digit plus sign 8421 BCD numbers from both the polarimeter and refractometer. For the polarimeter output, when the calculator is ready to receive the data, the RECORD button on

the interface is pushed. This immediately transfers the data into the X-register of the calculator. On the other hand when the calculator is ready to receive the data for brix, the reading is automatically transferred to the calculator from the refractometer. Programming the calculator in the desired format and interfacing of the polarimeter and refractometer presented no particular problems.

PROGRAMMING

The use of a programmed calculator in sugarcane breeding work was described in 1973 (4). However, information relating to brix and pol was manually keyed into the calculator.

The first step of programming is planning the sequence of calculator operations. Provisions were made for calculation and printing of 'Lab no.', 'Variety', 'Plot no.', 'Obs. brix', 'Temp.', 'Pol', 'Corr. brix', 'Sucrose', 'Purity', 'VCF', and 'Sugar/ton.' The program provides that the lab number increase by one for each sample analyzed. This number identifies the sample to be analyzed and becomes part of the permanent record. The variety and plot numbers or plot identification are typed manually on the printout. This allows easy and complete identification of the sample analyzed. Values for observed brix and pol are channelled through the electronic interface to the calculator and written automatically. Temperature reading for a set of 10 samples is stored in the memory of the calculator and recalled as needed. However, temperature corrections are not required when brix readings are taken with the automatic refractometer. Therefore, temperature corrections are not necessary and temperature reading can be dropped from the printout. The present calculator program includes the steps required to convert observed brix and pol to corrected brix and sucrose. Purity is derived by calculation as the relationship of sucrose to corrected brix. Values for corrected brix, sucrose, and purity are printed as calculated. Programmed steps necessary for estimating recoverable 96 pol sugar per ton of cane are derived from the method described by Legendre and Henderson (2). The milling factor or VCF is stored in the calculator and recalled as needed. The printout of the VCF and calculation and printout of sugar/ton are the final operations for a sample.

Corrected brix is used in this paper to mean percent soluble solids at 20C. In the event a brix hydrometer is used for observing brix, temperature corrections above or below 20C are found in tabular form (3) and are impossible to store with the limited storage capacity of the calculator. Regression equations were substituted for specific temperature correction for several ranges of observed brix, i.e., 7.50-12.49, 12.50-17.49, and 17.50-22.49%. The regression equations were then programmed; therefore, temperature corrections are made on the basis of the brix range represented by the observed brix. As an example, the following equation was substituted in the program for the table with observed brix in the range 12.50-17.49%:

$$Y = -1.1042 + 0.0569 X$$

where,

Y = Temperature correction, and

X = Temperature of the juice in C.

When using the automatic refractometer, observed brix is corrected brix and this step is omitted.

Apparent sucrose is derived from the expanded Schmitz's table when undiluted juices are clarified with dry lead sub-acetate (3). Observed brix and polarization (pol) are required to arrive at apparent sucrose from the table. Schmitz's table is long and could not be stored in the limited memory of the calculator. The formula used in preparing the table is:

$$\text{Apparent sucrose (\%)} = \frac{\text{Pol reading} \times 26.000}{\text{Apparent density @ 20C}}$$

For use of this formula in deriving sucrose, a regression equation is substituted for apparent density at 20C:

$$Y = 0.9940 + 0.0043 X$$

where,

Y = Apparent density at 20C, and

X = Observed brix.

The equation for apparent sucrose with the regression equation for apparent density was programmed.

Milling factors (VCF's) are assigned to all varieties, usually on the basis of comparative milling studies with the variety Co 281 as the reference (2). Information relevant to assigning VCF's are normal juice extraction percent cane, and brix and sucrose reduction factors. The compositonity formula for estimating recoverable 96 pol sugar/ton of cane was:

$$S_{96 \text{ pol}} = (s_c) (x) - (b_c) (y)$$

where,

$S_{96 \text{ pol}}$ = number of lb of 96 pol sugar recoverable
from a ton of cane,

s_c = number of 1% increments of sucrose in the crusher juice,

b_c = number of 1% increments of brix in the crusher juice,

x = calculated factor of 21.502, and

y = calculated factor of 6.238.

The two calculated factors, x and y , are stored in the calculator. As the VCF is given the x and y factors are recalled and adjusted. For example, the adjusted x and y factors for a VCF of 1.02 = 21.932 lb and 6.238 x 1.02 = 6.363 lb, respectively. Both the VCF and sugar/ton values appear on the printout.

RESULTS AND DISCUSSION

An automatic, electronic refractometer and polarimeter to measure brix and polarization (pol), respectively, are interfaced with a programmed calculator and output writer. The calculator provides all necessary calculations and the output writer provides a printout of the desired information, sample number, variety, plot number of identification, observed brix, temperature, corrected brix, pol, apparent sucrose, apparent purity, milling factor (VCF), and estimated recoverable 96 pol sugar/ton of cane. Only variety and plot number are typed manually, and temperature and VCF are keyed manually. Information from the refractometer and polarimeter is channelled through an electronic interface; calculated results are written automatically. The present program includes the program steps needed to convert observed brix to corrected brix, pol to apparent sucrose, and to calculate recoverable 96 pol sugar/ton.

Results of analysis for sample mill brix, polarimeter readings, and percent sucrose comparing several methods of determination are shown in Table 1. Values obtained for standard deviations and coefficients of variation indicate a close agreement for the methods described in this paper. In variety development, obtaining absolute values for cane quality, i.e., **brix**, percent sucrose, is not essential. Accordingly, none of the methods described here will give an absolute value for juice quality indices. However, in any method used the researcher must be able to separate varieties which may differ only slightly in their juice quality. Any of the methods described in this paper will perform that task.

This automation of analyses and calculations permits processing of 250 samples per 8 hour day by 2 technicians. It has increased efficiency of technicians, minimized error in observation and transcription of data, and provides legible tabular data that require minimum additional calculations.

Table 1. Analysis for sample mill brix, pol, and percent sucrose comparing the standard manual methods of determination and the automated/programmed calculation methods.

<u>Corrected brix (%) ^{1/}</u>	
Spindle brix w/tables - - - - -	14.84
Spindle brix w/program - - - - -	14.86
Refractometer brix (compensated) - - -	14.91
Standard deviation or s	= 0.04
Coefficient of variation or c	= 0.30%
 <u>Polarimeter reading ^{2/}</u>	
Manual - - - - -	60.1
Automatic - - - - -	60.8
Standard deviation or s	= 0.42
Coefficient of variation or c	= 0.69%
 <u>Sucrose (%) ^{2/}</u>	
Manual polarimeter w/Schmitz's table - - - - -	14.55
Manual polarimeter w/calculator program - - - -	14.57
Automatic polarimeter w/Schmitz's table - - - -	14.74
Automatic polarimeter w/calculator program - - -	14.75
Standard deviation or s	= 0.08
Coefficient of variation or c	= 0.57%

^{1/} Average of 18 samples processed 9/8/75, with juice temperature of 24°C.

^{2/} Average of 18 samples processed 2/17/76.

ACKNOWLEDGEMENTS

I thank Ms. Faye H. Seaberg, Physical Science Technician, U.S. Sugarcane Field Laboratory, Southern Region, Agricultural Research Service, U.S. Department of Agriculture, Houma, Louisiana for assistance in programming.

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A RAW JUICE MASS FLOWMETER IN A SUGAR MILL

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ABSTRACT

The authors describe a raw juice mass flowmeter, a magnetic unit with a density correction, which was tested during the past 1974-1975 crop. The article describes the measuring system, provides a list of equipment, and illustrates how it is connected. It also enumerates the advantages found.

Our sugar mill has gone through different expansion programs developed from 1963 to 1973, increasing the grinding capacity from 5,000 tons of cane per day to more than 12,500 per day. Our raw juice automatic scale was designed for a little more than the original 5,000 tons/day. In a short time, it was insufficient and a large amount of juice was necessary to be by-passed, reaching a point where the scale was not dependable.

We started investigating other ways to measure and weight accurately the raw juice coming from the mills, without the automatic juice scale.

As we all know, the raw juice as it comes from the mill has large amounts of entrained air, bagacillo, sand, mud, etc., and even with 17 or 18 degrees brix the specific gravity is under one (1.00). Tests have shown that a 16 degree brix raw juice mainflowing from the mill has an actual density of 0.95 as compared to 1.066 after standing for about 30 min. Orifice meters with that density variation have an error plus or minus 3%. Volumetric meter types have an error twice that value for the same conditions. Our main purpose was then to find a system to measure the volume and correct it for the density at the same time it was measured and, therefore, obtain a mass flow signal.

After different meetings with instrument representatives, we decided to buy a magnetic flowmeter and also install a density chamber with a D/P cell transmitter to correct the density at the time the juice is flowing through the magnetic flowmeter. Then the two signals, one from the magnetic flowmeter and another from the density transmitter, are sent to a computing relay before the signal is recorded and totalized.

Both instruments were installed in the line from the mill raw juice tank to the liming juice tank.

We favored the magnetic flowmeter because of the advantages it offered when handling a liquid such as raw juice with all the suspended solids' abrasive properties and the corrosive action due to the low pH.

It has free flow, no pressure drop, and with a proper lining to resist corrosion, it is practically maintenance free. The magnetic flowmeter utilizes the principle of electromagnetic induction to produce an a-c voltage signal which is directly proportional to the rate of the flow of the fluid through the meter. The accuracy is high and well within the limits of an accurate industrial application. The entrained air and impurities in the juice are measured by the magnetic flowmeter as volume is passing through it.

The electric output from the flowmeter is amplified and converted to a pneumatic signal and sent to the computing relay. The density signal is also sent to the computing relay. Here is where the flow is corrected for the density and a corrected output in tons/hours* (mass) is obtained.

This final output is recorded and totalized in a standard pneumatic recorder installed in an instrument panel. It works as follows:

In the diagram below we show how the system works:

To measure the density we use the in line density measuring chamber right after the juice passes the magnetic flowmeter. In this way, there is practically no time lag between the moment the juice flow and the density are measured.

Our system consists of the following elements:
(See schematic drawing).

1. One magnetic flowmeter in an 8 inch line with a capacity of 3,000 GPM.
2. One magnetic flowmeter amplifier-transmitter.
3. One current to pneumatic converter. (Transducer).
4. One pneumatic computing relay.
5. One pneumatic differential pressure transmitter for density measurement.
6. One purge water rotameter.
7. One two-pen standard pneumatic circular chart recorder - 24 hour chart.
 One pen 0-3,000 GPM
 One pen 0-750 tons/hr. with totalizer

We have been able to test this system during the entire past 1974-75 crop. So far, the results have been satisfactory enough to the extent that we are duplicating this system for the new mill in this year's expansion. The main advantages we have found are:

1. Accuracy of the system is plus or minus 1%, which is enough for the purpose intended.
2. Small space compared to the bulkiness of tanks and special equipment in other systems.
3. Little maintenance.
4. Low initial cost.
5. In case of large expansion in the mill, most of the parts or instruments remain the same. The only change that would be needed would be the size of the pipe and to recalibrate the system for the new grinding rate.

A comment from the author:

* Mass, as used conventionally, weight is synonymous with mass, pound per pound. Weight is an indefinite term since it depends on gravitational attraction that varies with location.

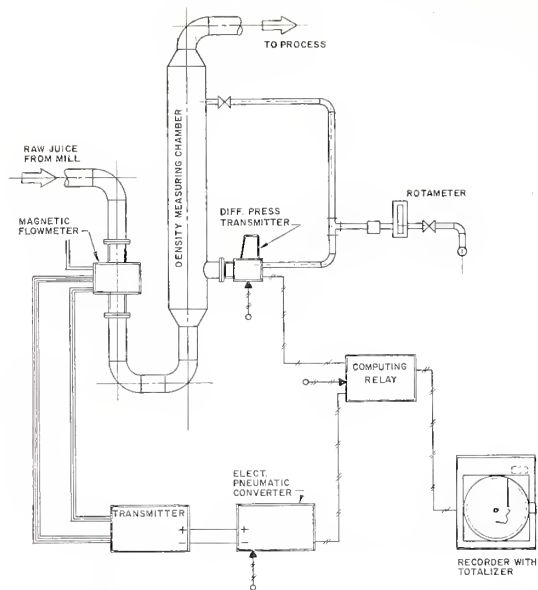


Fig. 1. Raw juice magnetic flowmeter with density correction.

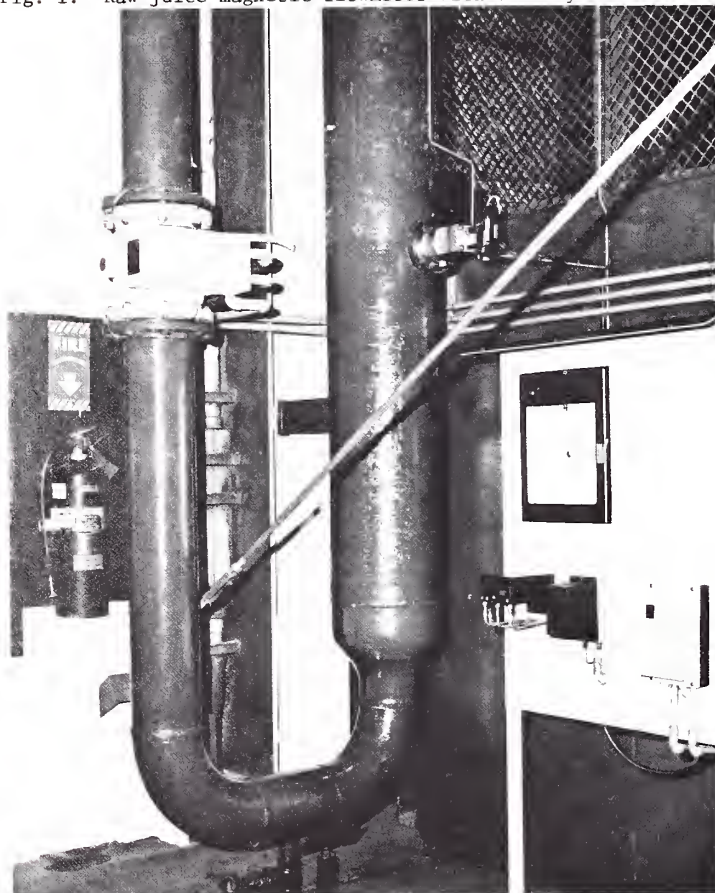


Fig. 2. Photograph of raw juice flow system.

EFFECT OF BIOCIDES ON SUCROSE RECOVERY AND
MICROORGANISM CONTROL IN CANE SUGAR RAW JUICE

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ABSTRACT

Microorganisms are used in fermentation processes during commercial manufacture of drugs, yeast, monosodium glutamate, vinegar, and beer and wine. These commercial applications are generally considered beneficial to the quality of life. Although cane sugar biological fermentation is a similar process, mill superintendents view microorganisms quite differently. Microorganisms degrade sucrose to form slimes that cause many manufacturing problems, including the following:

Difficulty in determining true percent sucrose in cane entering the mill

Lost production due to sugar degradation in the crusher

Slime and odor problems in the crusher system

Increased chemical requirements in clarification

Difficulties in filtration

Clogging of pumps, strainers, and pipes

Difficulties in obtaining satisfactory sugar crystals

The purpose of this paper is to show the effectiveness of microbicides in increasing sucrose yield and reducing processing problems by controlling the growth of specific microorganisms in the milling process.

MECHANISMS OF BIOLOGICAL DEGRADATION

Sucrose is biologically degraded stepwise to invert sugar (a mixture of glucose and fructose), and then further reacted to form polymerized polysaccharides called dextran. The simplified mechanism is shown in Fig. 1.

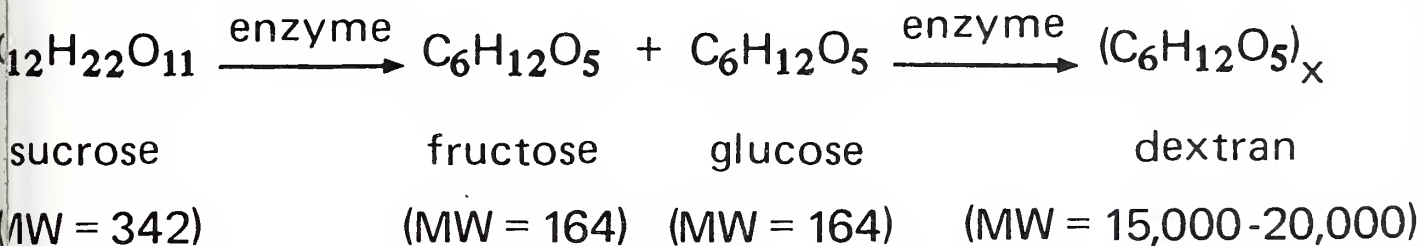


Fig. 1. Degradation of Sucrose

The first degradation step, where sucrose is degraded to invert sugar, is catalyzed by the enzyme invertase. The second step, the formation of dextran (molecular weight 15,000-20,000), is catalyzed by the enzyme dextran-sucrase. The formation of dextran is quite complex, as is shown in Fig. 2. The dextran chain grows by attacking sucrose molecules. Dextran is the gummy substance that causes most of the processing problems.

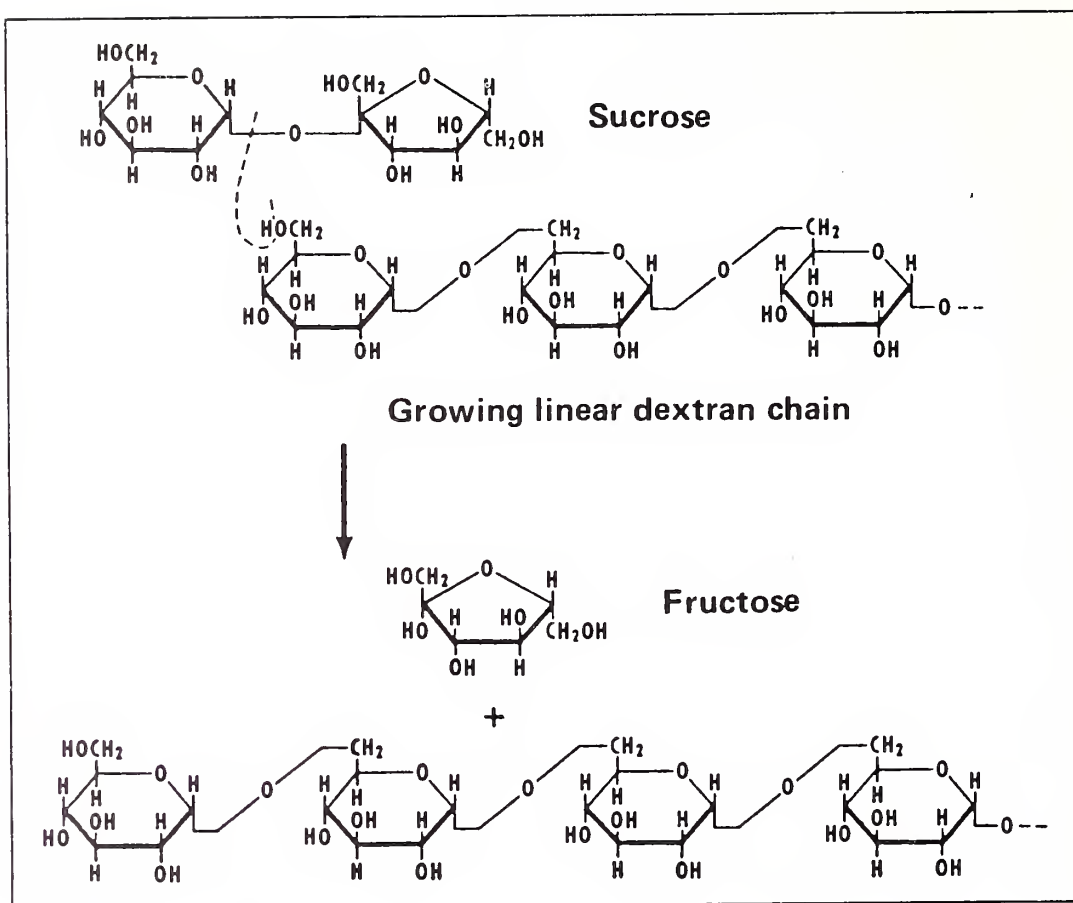


Fig. 2. Formation of Dextran by Dextransucrase

What is the source of the enzymes that cause sugar degradation? The chief culprit is *Leuconostoc mesenteroides*, which is the sucrose utilizing bacterium that produces invertase and dextransucrase. *Leuconostoc* is a microorganism that cannot be seen by the naked eye because one of these has a diameter of about 1/25,000 inch. However, that tiny organism reproduces in geometric progression, i.e., 1 → 2 → 4 → 8, etc., as frequently as every 20 minutes. This means that once *Leuconostoc* enters a nutrient medium a serious microbiological problem can develop very quickly.

The optimum temperature for *Leuconostoc* growth is 70-80 F. Outdoor temperatures and the temperature in the crusher circuit are ideal for the development of thriving colonies of *Leuconostoc* bacteria.

INFECTION OF CANE BY LEUCONOSTOC

A healthy, growing stalk of cane is not infected with *Leuconostoc*; the soil, however, is highly infected. The cane stalk is coated with a waxy substance that protects the inner stalk from infection. Whenever the stalk is damaged--by borers, freezing or cutting (harvesting)--it is immediately infected with *Leuconostoc*, which begins to multiply rapidly.

Experiments in Australia indicate that *Leuconostoc* can penetrate 3 inches from the point of cutting within 10 minutes. A 12-inch piece of cut cane (billet) can contain 10-100 million *Leuconostoc* within 24 hours.

Sugar losses in cut cane have been found to amount to about 4.5% after one day's storage and 12% after 2 days' storage. The suggested cure for the problem is minimizing the time between cutting and crushing.

PROBLEMS CAUSED BY LEOCONOSTOC IN THE CRUSHER

Since the transfer from cutting to crushing cannot be made instantaneously, the cane is already heavily infected with microorganisms when it enters the crusher. Freshly expressed juice normally contains 10^7 - 10^{10} sucrose-utilizing organisms/ml.

Thus, conditions are right for continued rapid reproduction of *Leuconostoc*, resulting in continued sugar loss and increasing amounts of dextran. Sugar loss, of course, means lost bags of sugar, but another major problem is the gummy deposits that dextran form.

Gummy dextran slimes coat the crusher system and can float like "frog eggs" in the juice (and accumulate in the mixed juice tank). The slimes can clog strainers, pumps, and pipes, and permeate the crusher area with quite unpleasant odors. There have been cases where sugar mills have been choked completely by slime when cleanliness was neglected.

PROBLEMS CAUSED BY LEOCONOSTOC BEYOND THE CRUSHER

Leuconostoc is killed when the raw juice is passed through the heaters prior to liming. Table I shows that the juice is sterilized during the clarification process and that microorganism growth is not significant downstream in the process.

Table 1. Concentration of slime forming microorganisms in various parts of the process

Product	Dextran formers (microorganisms/cc)	
	Low	High
Raw juice*	8,000,000	16,000,000
Raw juice**	570,000,000	750,000,000
Clarified effluent	0	11
Press juice	0	51,000
Evaporator	200	33,000
Storage tank	13,000	7,100
Crystallizer	2,000	44,000
Masseccuite	1,200	10,000
Raw sugar (gram)	340	5,100
Molasses	3,000	210,000

*Early in the season.

**Late in the season

The first problem area is the clarifier, where increased chemical usage will be required, depending on severity of the slime. Mud filtration is more difficult because of slimes in the mud.

The problems continue to the evaporators where slime carryover can add to the deposits on the heat-transfer surface and any other metal surfaces.

Dextran in the thick juice will increase the viscosity and can cause poor crystallization. A dextran content of 1% (solids basis) can double the viscosity of the thick juice. Uncontrolled microorganism growth would be disastrous to the operation of a cane sugar mill.

DETERMINATION OF SEVERITY OF MICROBIOLOGICAL PROBLEMS

There is no practical absolute method of relating microbiological activity to sugar loss because of variations of sugar content and microbial infection in cane taken from different fields. Mills do not process cane from one field at a time. Several fields are harvested simultaneously and brought to the crusher or cane pile. The mill processes a "mixed bag." Therefore, some indirect methods of determining sugar loss are used rather effectively by experienced mill personnel.

Some of the methods used to determine the degree of microbiological problems follow:

Slime deposits in the crusher system.

"Frog eggs" in the mixed juice tank.

Foul odors in the crusher area.

Determination of sucrose utilizing bacteria counts.

METHODS FOR CONTROLLING MICROORGANISMS

Physical Methods. Cane should be processed as soon as possible after harvesting to minimize both sucrose loss in the field and the level of infection in the process system.

Good Housekeeping. Daily hosing of mills, conveyors, and screens with hot water and steam will minimize equipment fouling and microorganism level.

Application of Biocides. The prevalence of microorganisms in freshly extracted cane juice and their ability to induce losses in recoverable sucrose have resulted in a great deal of study of means to reduce these losses by the addition of certain effective bacteriostatic agents to the juice. As discussed earlier, the sugar cane stalks, as delivered to the mill, contain a high concentration of bacteria.

The application of modern bacteriostatic compounds for the prevention of mill losses is beneficial and will prove especially effective when grinding damaged cane. Damage by freezes or by the infestation of cane borers results in the almost immediate initiation of microbial action on the extracted juice, lowering its sucrose purity and producing appreciable quantities of dextran gums. The changes thus induced in the extracted juice increase the difficulties of clarification and result in reduced yields. In such circumstances, the bacteriostatic agents are especially effective.

MONITORING PERFORMANCE OF BIOCIDES

Indirect Methods.

1. Look for slime deposits in the crusher circuit.
2. Look for "frog eggs" in the mixed juice tank.
3. Smell for foul odors.
4. Determine sucrose utilizing bacteria counts on a regular basis, and plot them on a graph so that detection of unusual microbial trends is easy.

These methods are subjective, but effective.

Direct Methods.

1. Polarimetry analysis for sucrose.
2. Liquid partition chromatography analysis for sucrose.

A study was undertaken to determine the effect of biocides in mixed juice by microbio counts of *Leuconostoc* as well as percent sucrose by liquid chromatography. This direct method of sucrose analysis eliminates the influence of other optically active substances, particularly dextran influence, which is not resolved by polarimetry. A quantity of mixed juice from the mill was dispensed into two 500-ml volumetric flasks. One flask was filled to the mark with the mixed juice without biocide and served as the control. To the other flask 21 ppm of biocide was added; the flask was then filled to the mark with mixed juice, serving as the treated sample. Immediately a 10-ml aliquot was removed from each flask and placed into a sterile tube; then a microbio analysis was run for *Leuconostoc* bacteria. After removal of the sample for microbio analysis, the tubes were placed in a dry ice-acetone bath for instantaneous freezing. Temperature of this bath was about -80 C. This represented the zero-hour sample. This same procedure was followed for the time intervals of 15, 30, and 45 minutes; 1, 2, 3, and 4 hours. The tubes were kept frozen until defrosted for the liquid partition chromatography analysis.

The two 500-ml flasks remained at ambient temperature (86 F) throughout the test, loosely capped, with no agitation. A serial dilution of each sample was made for microbio analysis with sterile deionized water. Sterile pipets, plates, and general aseptic technique were employed to avoid any extraneous contamination. Pre-sterilized media were melted on site, cooled and poured. The plates were incubated at 86 F for 48 hours, and the number of *Leuconostoc* per ml of original sample was recorded.

The method used in determining percent sucrose by liquid chromatography consisted of defrosting the sample, centrifuging, and injecting an appropriately diluted aliquot of the supernatant into the chromatograph. With the advent of high pressure liquid chromatography systems and specially designed packings, saccharide analyses can now be accomplished directly and rapidly. Resolution is distinct and reproducible. Sample preparation is simple and does not require derivative formation.

Percent sucrose was quantitatively determined by computer peak area measurement. The procedure generally followed that described in Water Associates, Inc. AN 132, December, 1973, "Separation of Saccharides by Liquid Chromatography."

RESULTS

A regression analysis was run on the microbio data, and the best curves were plotted by computer. Fig. 3 compares *Leuconostoc* growth in the untreated and treated samples over time. After about 5 hours, the number of microorganisms in the sample treated with biocide is much lower than in the control.

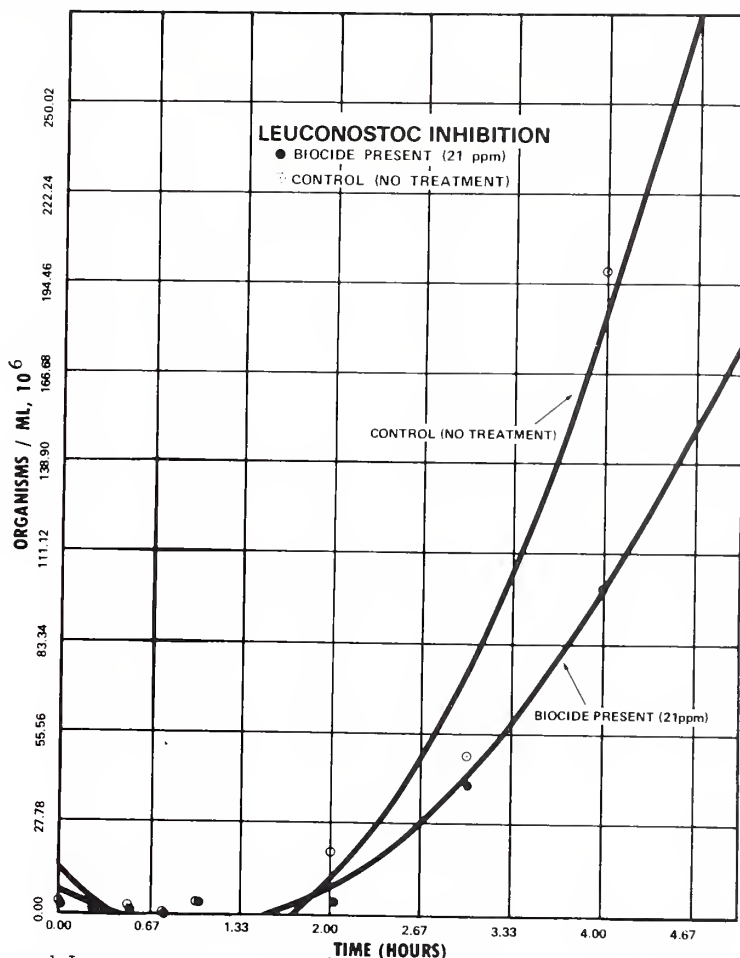


Fig. 3. Graph compared *Leuconostoc* concentration in the control sample with that in the sample treated with 21 ppm biocide.

In Fig. 4, percent sucrose in the control and treated with samples are compared. The regression analysis of the sucrose data reveals a decline in percent sucrose with no biocide, while the treated sample remained fairly level through the same time span, indicating an average savings of 0.1% sucrose as a result of treatment with biocide.

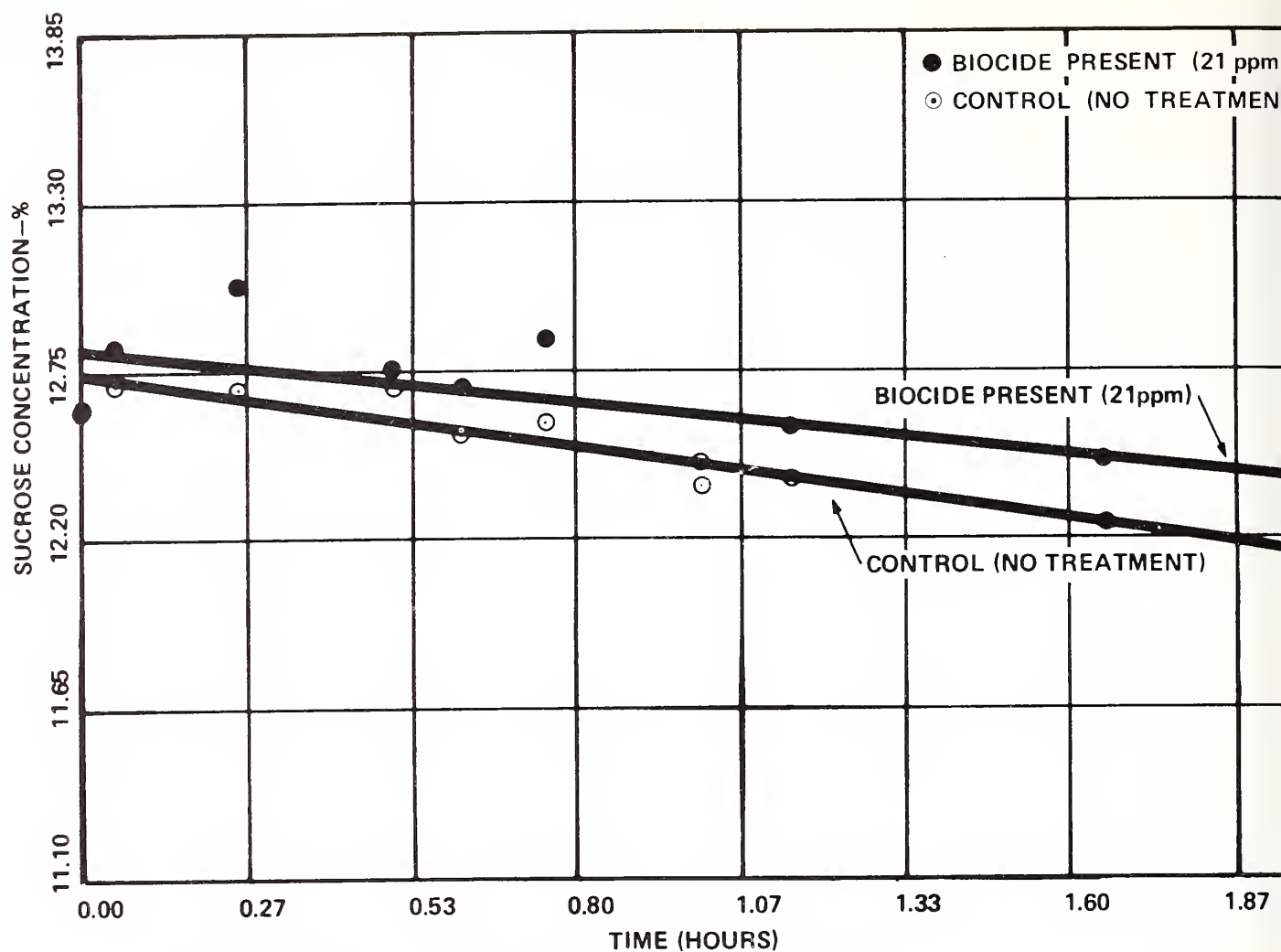


Fig. 4. Sucrose yield is greater with biocide treatment than without.

CONCLUSION

As stated earlier, microorganisms, specifically *Leuconostoc*, enter the crusher and rapidly reproduce, resulting in continued sugar loss and increasing amounts of dextran. Results of this study indicate the presence of *Leuconostoc*, which caused sucrose degradation in the milling system. Treatment with biocide reduced *Leuconostoc* and increased sucrose yield. In addition to increasing the sucrose obtained, the reduction in *Leuconostoc* microorganisms should provide better plant operating conditions.

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EXPECTED PROBLEMS OF THE SUGAR AND RELATED INDUSTRIES
IN MEETING E.P.A. STANDARDS

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Trevose, Pennsylvania

ABSTRACT

This paper presents a brief discussion of the problems expected to be encountered in meeting Environmental Protection Agency air and water standards.

HEAVY-DUTY CHOPPER-FIBERIZER

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ABSTRACT

A machine for the preparation of sugarcane prior to milling or diffusion combines, in a single unit, the effects of a cane knife and a shredder. The single rotor performs two different operations simultaneously, at two completely different points, i.e., chopping the cane at the feed side, while shredding the chopped cane at the opposite side of the rotor.

USE OF PACKAGE BOILERS IN THE SUGAR INDUSTRY

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Betz Laboratories, Inc.

Present market conditions and legislative consideration have caused a boom in plant expansions in the cane sugar industry. As we all know, before you can grind more cane, you must produce more steam. Few mills have the capacity to produce this steam without the installation of new boilers.

Having decided to purchase new boilers, the mill has two choices. It can purchase a field erected or package boiler. A very basic comparison of these two shows us the following:

<u>Field</u>	<u>Package</u>
Several years delivery	Relatively short delivery
Bagasse fired	Oil fired
High abuse factor	Low abuse factor
Expensive	Less expensive
Ease of maintainence	Less easy to maintain

Perhaps the most important consideration today is delivery time. Since additional power is needed as soon as possible, most mills have chosen package boilers.

Most package boilers follow one of three configurations: A, O, or D. The letters conform roughly to the shape of the head-on view of the steam drum, tubes, and mud drum or headers.

The A type configuration is composed of a large top steam drum and two lower headers, one on either side of the steam drum.

Both O and D types have one steam drum directly above one mud drum, the difference in designation being tube configuration.

Of the aforementioned boilers, the A and O types expose less tube area to radiant heat. The D type allows easier installation of superheaters to the radiant or convection zone and can offer longer residence time for hot gasses.

The comparison of the field erected boiler with the sturdy, dependable plowhorse is similar to equating the package boiler with the tempermental thoroughbred. This analogy becomes particularly apt when one considers the water treatment needs of the package boiler. The field erected boiler can often operate with some scale, perhaps 1/16" or even 1/8" in colder areas. This much scale would cause tube failures in a modern package boiler.

Consideration of water treatment must begin with the source of the water. In the sugar industry the sources are: wells, city, surface, and condensate (process and boiler). Each offers its own problems.

Wells tend to be high in iron. This iron not only fouls the resin used in zeolite softeners and demineralizer systems but can cause the most difficult scale to remove from boiler heat exchange surfaces. Iron can be removed by one or more of the following external treatments:

- 1) Cation - exchange softening
- 2) Aerate or chlorinate and filter
- 3) Aerate, settle, and filter
- 4) Oxidizing filters

There are also internal treatments used to prevent iron deposition. These will be covered later.

Surface waters often contain silt and organic contamination. Both silt and organics can foul external treatment systems and create internal problems in boilers.

City water is expensive and often is as contaminated with iron as the surface and well supplies and has the added problems of chlorine attack on zeolite resins.

Process condensate is excellent feedwater but can contain organics, sugars, and calcium if carryover occurs. The usual safeguard is to collect process condensate and test for sugar using the alpha naphthol test before feeding the condensate to the boilers. Should sugar contaminated water enter the boiler, the sugar converts to CO₂, lowers the boiler pH to the acid side, and causes foaming and carryover. Field erected boilers can take several such upsets in a season, but such upsets in a package boiler can cause loss of tubes, plugging of steam purification systems, and severe metal loss from boiler internals and condensate systems. This carryover is most severe when boiler cycles are high and sugar carryover occurs.

Boiler condensate is excellent feed water but can contain iron if CO_2 is present in the steam. The use of a chemical condensate return treatment or condensate polishing systems can eliminate this problem.

External water treatment selection is dependent on the source of the raw water, the pressure the boiler will operate at, and the amount of condensate available. The most common external treatment for package boiler systems up to 350psi is sodium zeolite softening. Demineralization is employed for boilers in the 600psi and higher range.

The important point to remember is: Internal treatment is not a substitute for poor external treatment.

Internal treatment for package boilers falls into two categories: chelants and phosphates. Both chelants and phosphates should be used in conjunction with dispersants (also called sludge conditioners and scale controllers).

Chelants are of two types, EDTA (ethylenediamene tetra-acetic acid) and NTA (nitrilo triacetic acid). The sodium salts of these two acids are used to chelate calcium and magnesium in boiler feed water. These agents give cleaner tube surfaces and better heat transfer than phosphate programs. They do require better control as far as in plant testing and service by water treatment representatives are concerned. Of the two treatments, EDTA has the advantage of chelating soluble iron and preventing the deposition of iron scale discussed previously.

Some boiler manufacturers state in their literature that headers of A type package boilers should not be blown down. This means no sludge blowdown and eliminates phosphate type treatments from consideration unless makeup is 100% condensate and contains no iron. However, it is interesting to note that while these companies do not recommend blowing down headers, they equip the headers with sludge traps and blowdowns.

Before the decision to go to chelants is made consult your water treatment consultant, as chelants can be employed economically only when feed water hardness is 2ppm or less. Chelants also require different feed systems than do phosphates. Chelants should never be fed directly to the boiler as are phosphates.

When phosphates are used in package boilers, care should be taken to keep sludge to a minimum by the use of the proper dispersant at the proper levels. Various dispersants are designed to disperse calcium (and modify its crystalline structure), iron, copper, and calcium phosphate. The selection of dispersant depends on numerous factors and should be discussed with your water treatment representative. Recent studies show PMA (polymethacrilate) and CMC (carboxymethylcellulose) to be the best dispersants for calcium and iron, respectively.

Oxygen attack is a serious problem in all boilers, particularly when economizers are present. Efficient deaeration and the addition of an oxygen scavenger below the working water level of the deareator are required. These oxygen scavengers are sulfites (both catalyzed and uncatalyzed) and hydrazine. The increased reaction rate makes catalyzed sulfite the usual choice. Sulfite usage should be watched closely as an increase in consumption indicates air leakage into feed water or problems with the DA heater.

Condensate corrosion is usually caused by CO_2 but can be aggravated by small amounts of oxygen getting into condensate receivers.

External treatments such as lime or lime soda softening, chloride dealkalization, hydrogen zeolite and demineralization can all reduce carbon dioxide content of feed water. If process condensate is used as makeup, the ammonia content is usually more than enough to neutralize feed water CO_2 until sugar is carried over. When this happens, the sugar gets to the boiler, the boiler water pH drops to 4 or below, and the only remedy is to feed caustic, a neutralizing amine and blowdown the boiler at its maximum until the pH of the boiler returns to the alkaline side (above 7). While some field erected boilers have taken this abuse for years, this type of abuse could shorten the life of a package boiler or cause its total failure. Remember that with a package boiler you have lower volumes of water and much high heat inputs per square inch of surface area. For this reason, it is advisable to collect process condensate and test it for sugar before using it as feed water, any trace of sugar should be reason for rejecting process condensate for package boiler feed water.

The two most common neutralizing amines are morpholine and cyclohexylamine. To choose one or a mixture depends on a number of factors such as boiler pressure and contact of the steam with food products or containers.

The use of filming amines in the sugar industry is generally not recommended as organics and inorganics in process condensate during periodic carryover react with these type products. Only the simpler type of film formulae are approved for FDA type uses and have been known to plug lines and in general to disrupt the entire power plant operation.

Package boilers require better external treatment, better internal treatment, and more control. In addition, when purchasing such equipment as a package boiler remember drum size and steam disengaging space are important due to the upset potentials of sugar operation. Don't let price considerations drive you into situations that you will later be unhappy with. Discussions ahead of time can be good for all interested parties.

When package boilers are used as a standby power source, the most economical method of keeping the boiler hot and ready for use is to run the blowdown water from a field erected boiler to the package boiler. This blown down water should enter a lower drum by way of the blowdown valve and exit from the continuous blowdown.

The fireside problems encountered in oil fired package boilers are quite different from those found in the combination oil-bagasse boilers often used in the sugar industry.

An examination of fireside problems must begin with an examination of oil itself. Unless otherwise mentioned, the oil discussed will be No. 6 or Bunker C oil.

Number 6 oil is a relatively high sludge oil. This sludge is caused by asphaltines, oil water emulsions, products of polymerization and oxidation as well as carbon particulates. This sludge can settle to the bottom of storage tanks, particularly in the offseason, and reduce oil storage space. This sludge can cause storage tank corrosion at the point of interface or where the water layer settles out in the tank and reacts with the sulphur in the oil to produce acids. Sludge can build up as deposits in oil lines to the boiler and reduce the flow capacity of the line enough to require cleaning. These are the same type deposits that cause frequent strainer and inline heater cleaning. The passing of relatively large sludge particles through pumps can cause excessive fuel oil pump wear and replacement. Deposition in burners will distort flame patterns, reduce maximum load, necessitate frequent burner cleaning, and make normal cleaning more difficult. Sludge is a problem that can be solved with a fuel additive. These additives are organic solvents, dispersants, emulsifiers, or combinations of them. Since sludge has a BTU value of 150,000, the use of a proper fuel additive not only solves the abovementioned problems but increases overall operations efficiency. It allows the combustion of this material which would otherwise just be a problem-causer.

Problems with fuel oil get more complex as we get into the boiler. Excess air control is necessary not only for efficient operation, but for operation with clean stacks. Since air is 79% nitrogen, a loss of efficiency comes with each cubic foot of excess air (79% noncombustible) that is forced into a boiler. Package boilers normally run 10 to 20% excess air. Combustion catalysts (when all other factors are well controlled) can aid in the lowering of excess air requirements and thus save 1 to 2% of fuel needs.

Most package boilers come with fuel feed systems sufficient for boiler needs, but these feed systems are sometimes misused or poorly maintained. No fuel additive or combustion catalyst will help with these problems. One typical example is burner positioning. Burners are locked into place in package boilers, but these locks sometimes become worn and allow the burner to move out of position. At other times the burner is purposely moved. If the burner tip is too far back, preignition and carbonization will occur. If too much steam pressure is used or oil temperature is too high, the flame is pushed too far from the burner tip to burn. The indication of this is the presence of bright orange sparklers in the flame and a dark tail end.

These are examples of some of the many problems that oil additives will not solve. Oil additives are not a substitute for poor combustion control.

Bunker C oil contains large amounts of impurities. The type and quantity of these impurities is dependent upon the crude source, methods of refining, transportation, and storing. As a result of these impurities, many fireside problems are encountered:

- 1) High temperature slag
- 2) High temperature corrosion
- 3) Low temperature corrosion
- 4) Cold end fouling
- 5) Acid smut conditions

In the boiler, noncombustible impurities such as nickel, vanadium, and sodium become molten and form complexes that adhere to furnace and tube surfaces. This slag causes several problems. It enters the refractory in a molten form and upon cooling expands and breaks up the refractory. This process is called spalling. Slag adheres to super heaters and collects along with impact ash in the convection pass causing loss of efficiency and restricting gas flow. This is

particularly true of package boilers where gas turns are sharp. Molten slag is itself corrosive and causes high temperature corrosion by removing the protective oxide coating from tube surfaces and exposes metal surfaces to further corrosive attack. Unless cooled surfaces such as tube hangers spacers are most prone to high temperature corrosion. High temperature corrosion can also be experienced when tubes are scaled on the water side impeding heat transfer and raising metal temperature.

The vanadium compounds in slag also have the capability of catalyzing the sulfur dioxide with excess air to form sulfur trioxide. The sulfur trioxide will condense at the cold end of the boiler to form sulfuric acid. This acid combines with gas particulates to form acid smut that is highly corrosive and restricts gas flow.

All of the slag problems can either be eliminated or markedly reduced by the proper application of a fuel additive. These additives are usually slurries of magnesium and aluminum oxides or liquid magnesium compounds. The magnesium combines with the low melting point ash and creates a eutectic that has a melting point higher than the ash but lower than the magnesium oxide. These higher melting point eutectics can be removed by attrition of the flue gas or by soot blowing. The magnesium also limits the effectiveness of vanadium as a sulfur dioxide catalyst.

Care should be taken at the start up of any fuel additive program as overfeed or misapplication can cause problems from excessive wear to excessive ash.

No discussion of fuel oil problems would be complete without mention of cost as a major problem. The cost factors can be reduced by increases in efficiency. Some examples of places to look for efficiency increases and/or heat savings are:

- 1) Use of flash tanks to recover heat from process and blowdown steam. The low pressure steam from flash tanks can be fed to the DA heater to increase feed water temperature. (The hotter the feed water the less oil is necessary to produce steam).
- 2) Insulation of condensate return lines, condensate tanks, boiler drums, and DA heaters. Again, every 154,000 (approx.) BTUs you save one gallon of No. 6 oil at \$.30 to .36 a gallon.
- 3) Increase in boiler cycles.

The less you blow down, the less heat goes to the drain. However, it is important that an increase in cycles must follow a boiler inspection (particularly steam purification equipment) by a competent water treatment consultant and increases in cycles made slowly while a steam study using the sodium tracer technique is in progress. The degree of steam purity will, of course, depend upon the steam usage. Steam for heating an evaporator need not be as pure as steam to a turbine. When process condensate is used, cycles higher than Bureau of Mine standards or American Boiler and affiliated industries should be run only if sugar contamination possibility is eliminated.

Use of a viscometer to measure oil viscosity in the line and adjust the oil heat accordingly not only saves oil but keeps the fireside cleaner.

The procedure for the removal of a package boiler from the line is of primary importance. In operation, the boiler water contains suspended solids (or mud) which are held in suspension by water circulation and the action of treatment. Unless care is exercised when draining, these suspended solids settle out on the boiler surfaces and air dry to an adherent deposit; sometimes requiring turbing of the boiler. In addition, unless the deposits are examined carefully, it may be assumed incorrectly that the deposits are scale which formed during operation. Therefore, in order to judge the effectiveness of the water conditioning program as well as to eliminate unnecessary boiler cleaning, proper care is imperative during shutdown.

For a period of three to seven days before shutdown, manual blowdown should be increased. During this period, the lower conductivity or chloride limit should be observed as a maximum. The feed of internal treatment must be increased to maintain specific residuals. Continuous blowdown should be kept to a minimum so the reduction in solids is achieved by increased manual blowdown.

If it is necessary to use a draw-and-fill method for cooling, the pressure should be lowered and cooling should be at the rate recommended by the boiler manufacturer. Care should be taken to maintain recommended treatment balances during this process. Feedwater should be deaerated.

Immediately on draining the boiler, the manhole or manholes should be knocked in and a high pressure hose employed to wash out sludge. By this procedure, the sludge is removed while still in a fluid form.

If the boiler cannot be washed immediately on draining, heat in the boiler setting may cause baking of sludge. By this procedure, the sludge is removed while still in a fluid form.

If the boiler cannot be washed immediately on draining, heat in the boiler setting may cause baking of residual sludge. The boiler should not be drained until cool. However, never leave the boiler filled with water for any extended period of time without taking measures to prevent corrosion and pitting.

Unless certain precautions are taken, corrosion may occur on external and internal surfaces of the boiler out of service for any length of time.

The dry storage method is recommended whenever a boiler is to be out of service for a long period, and time will be available to prepare the unit for operation.

If possible, all horizontal and nondrainable boiler tubes and superheater tubes are to be blown with compressed air. Particular care must be taken to purge water from long horizontal tubes that may have bowed slightly.

Heat should be applied to dry the setting, and then the unit should be closed to reduce air circulation. Whenever necessary to maintain the temperature of all surfaces above the dew point, heaters should be installed.

Immediately after surfaces are dried, one of the three following dessicants is to be spread on water-tight wood or corrosion-resistant trays.

Quick Lime--used at a rate of six pounds per 100 cubic feet of volume

Silica Gel--used at a rate of eight pounds per 100 cubic feet of volume

Activated Alumina--used at a rate of eight pounds per 100 cubic feet of volume

Locate trays in each drum of a water tube boiler, or on the top flues of a fire tube unit. Tightly blank and close all manholes, handholes, vents and connections.

Although dry storage is preferred, a wet method is acceptable whenever a boiler is on emergency standby.

I would be happy to supply information on wet storage to anyone who wishes to ask me about it.

Automation of the continuous blowdown reduces excess blowdown due to human error to a minimum, and thus reduces the amount of heat to the sewer increasing overall efficiency.

In summary, the efficient and reliable operation of a package boiler fireside system can be enhanced by the proper selection and application of a fuel additive and proper internal treatment, as well as improved control of mechanical systems.

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ELECTRONIC STEAM PURITY STUDIES
INSURE CLEAN RELIABLE CANE MILL ENERGY

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ABSTRACT

An abundant reliable source of clean, high-quality steam is a key factor in any successful sugar campaign. Monitoring several steam generators, using the sodium ion selective electrode technique, identified potential operational problems. Changes in boiler-operating parameters and water-treatment practices were monitored to ensure that the corrective measures were effective. The data gathered during these studies and the results obtained from operational changes are presented in this case history.

INTRODUCTION

At the ASSCT Convention in October, 1974 held at Clewiston, Florida, we had the opportunity to present a paper entitled "The Utilization of New Approaches and Techniques in Improving Boiler Plant Operation Efficiencies."

The paper emphasized various phases of boiler plant operations by a detailed explanation of the following specific subjects:

1. Steam purity studies. This section dealt with a sophisticated method for analyzing steam purity and explained how optimum steam quality could be obtained while at the same time substantially effect a reduction in continuous blowdown, further improve the overall boiler water treatment program, and in summary show how the overall boiler operation efficiency was improved.

2. Sodium elution studies. This section dealt with an inexpensive and practical technique for evaluating softener regeneration procedures. It demonstrated how to analyze for either loss of exchange capacity or hardness leakage, particularly when the hardness in the softener effluent would occur on a regular basis.

A detailed explanation was provided on the use of the brine hydrometer and how it is used in pinpointing the exact causes for any hardness leakage. The paper dealt with the actual efficiency improvement that would result because of the hardness reduction in the feedwater which would reduce chemical costs, more efficiently use the salt required for each regeneration, and improve the internal cleanliness of the overall boiler system thus increasing the heat transfer and ultimate efficiency improvement.

3. Deaerator studies--achieving the oxygen guarantee. This section dealt with proven practical methods of how to measure dissolved oxygen in the deaerating heater effluent and with the numerous factors and variables that must be controlled to achieve the oxygen guarantee of the heater.

4. Fuel cost savings using boiler fireside treatments. This section detailed various techniques relative to combustion improvement, slag prevention, and overall efficiency improvement on bagasse fired boilers.

A copy of the above paper is available to those of you who are interested or who have not received the paper.

The objective of this paper is to explore, in depth, the first topic of our October presentation, which dealt with steam purity and the operating results that could be achieved from such a study.

Since October, 1974, we have had the opportunity to run many steam purity studies at several Florida sugar mills using the sodium ion selective electrode method. The results from these studies have varied substantially from each other, revealing unique information, characteristic of the particular boiler or boiler plant tested. We would like to share with you a specific case history on one of those studies and the resulting benefits that were derived from such an in-depth steam purity analysis.

The purpose of these steam purity analyses and the resulting case histories center around the concept that an abundant, reliable source of clean, high quality steam is a key factor in any successful sugar campaign. If clean steam is not produced, operational problems can result in reduced production rates, downtime for repairs/cleaning and, potentially, in serious damage to equipment.

The quality of your steam can now be accurately and continuously measured in your own plant during your routine operations. That is, you can now determine the quality of your steam during all phases of your operational day and can observe the changes in steam quality and the relationship they have to changes in boiler operation. As a result, you can make the appropriate corrective decisions before difficulties arise.

To accomplish this technical service, we employ a steam purity analyzer, specially designed for field use, that uses the sodium ion selective electrode technique for determining steam quality.

Impurities in steam may be solids, consisting of alkali and alkaline earth salts of chloride, sulfate, phosphate, sulfite and silica present in the boiler water; liquids such as hydroxides at superheated temperatures and pressures; or gases, including ammonia, carbon dioxide, sulfur dioxide, hydrogen sulfide and volatile amines, contained in the feedwater or generated within the boiler.

While the steam purity guarantee for most modern, high pressure steam generators is 1.0 ppm or less of total solids for given boiler conditions, deposition in superheaters or turbines can be minimized by producing steam of greater purity.

Maximum steam purity results from optimization of a steam generator's internal mechanical devices and correct operating parameters such as chemical boiler water treatment, pressure, load and water level.

Steam purity, determined by a tracer technique such as the sodium ion analyzer, involves testing for a component of the solids present in the boiler water that can be expected to be present in the steam. The ratio of that component to total solids in the steam must be the same as in the boiler water. The sodium ion, normally the ion found in greatest concentration in boiler water, can be used to monitor steam purity.

The actual steam purity is determined by measuring the ratio of sodium ions to total solids in the boiler water at representative times throughout the study and assuming the same ratio of sodium ions to total solids in the steam exist. In high pressure units, this ratio may be upset due to volatile sodium compounds and is taken into consideration.

Simple steam purity measurements for a particular steam generator involves monitoring the condensed steam's sodium ion activity under normal water treatment and operating conditions for a representative period of time.

When steam purity fluctuations are suspected or confirmed, a test program is organized to investigate the effect of each of the following variables on the sodium ion content of the condensed steam, while operating the steam generator under normal conditions: (1) boiler water concentration of total solids, (2) load fluctuations, (3) water level changes, (4) chemical boiler water treatment changes, (5) pressure changes, (6) boiler firing pattern changes, (7) any combination of the above.

In most cases, steam purity is directly proportional to boiler water carryover into the steam system. The origin of carryover is not always clearly defined, but some of the more common causes are either mechanical, chemical or combinations thereof. Some of the more common mechanical causes are: poorly fitted steam drum internals, baffle leakage, feedwater distribution line leakage, firing of the boilers, operating boiler over rated capacity, poor design of water separation equipment, high water level and/or variable control, and rapid load fluctuations.

Some of the more common chemical causes are: feedwater and condensate quality, chemical foaming tendencies of the boiler water, boiler water solids control, foaming, organic contaminants (sugar and oil, etc.), and any combination of the above.

In multiboiler systems, using a common header, care must be taken to identify the offending unit and the conditions under which it contributes to the overall problem. In these cases, multisampling points are required and some preliminary screening work must be done before the in-depth program proceeds.

EXPERIMENTAL PROCEDURE

Apparatus: The steam purity tests were conducted using a field model sodium ion analyzer equipped with a sodium ion selective electrode, standard calomel reference electrode, and a continuous recorder.

The steam sampling nozzles were multiport-type isokinetic sampling nozzles, constructed and installed according to the American Society for Testing and Materials D1066.

The studies were performed according to ASTM D2791, using a glass electrode (sodium ion electrode) made insensitive to ions other than sodium, specifically hydrogen ions. Condensed saturated steam, obtained from a properly constructed and installed standard ASTM steam sampling nozzle, and a specified ASTM sampling circuit having a temperature of approximately 25 C is passed through a flowmeter regulator and is mixed with gaseous dimethylamine from a regulated compressed gas cylinder where the sample stream is elevated to a pH of 11.0 or higher. The conditioned sample stream then enters a flow chamber where the electrode system, consisting of a sodium ion-sensitive electrode, reference electrode, and automatic temperature compensator, produces a voltage output proportional to the sample stream's sodium ion activity. In these very dilute solutions, ion concentrations and active ion concentrations are essentially equal. The voltage output is displayed on a monitor in concentration units and recorded on a strip chart recorder.

Reagents and standards: 99.0% (minimum) pure anhydrous dimethylamine was used to buffer the sample stream to pH 11.5. Sodium standards were prepared by placing various aliquots of standard 10.0 ppm Na⁺ solution (15.4 ppm NaCl, reagent grade) in deionized water. Buffered sample effluent was added to each standard bottle on site to result in sodium ion standards of 1.000, 0.100, 0.050 and 0.010 ppm Na⁺. Accuracy of the original sodium standard solution was verified by atomic absorption and conductivity measurements.

Normal operation conditions of the sodium ion analyzer were:

Sample stream flow rate	100 ml/min.	± 10
Sample stream pressure	75 psi	± 5
Sample stream temperature	23°C	± 2
Sample stream buffered to pH	11.5	± 0.5

Steam and condensate were allowed to purge the sample line and cooler for 4 to 8 hours prior to attaching the sodium ion analyzer for recording purposes. Electrodes were transported in a wet state to avoid the normal 24-hour hydration period.

After one hour of constant sodium ion response at the operating parameters shown above, the analyzer was calibrated.

The electrodes were immersed in the 1.000 ppm Na⁺ standard using a specially prepared polyethylene bottle, the instrument was then allowed to equilibrate on a range $\times 10^2$ and the calibration knob was adjusted until the indicating meter read 10×10^2 ppb, which is equal to 1.0 ppm. The 0.1 ppm Na⁺ standard was then used to verify the calibration.

Samples of boiler blowdown were taken at representative times throughout the steam purity studies and fixed in order that appropriate analyses could be conducted at our Central Regional Laboratories for further confirmation. Sodium ion concentrations of these samples were determined by an atomic absorption method. The total solids of the submitted samples were determined by a gravimetric technique according to ASTM D1888.

In addition, other determinations were made, both on-site and in the Central Regional Laboratory, for such problem contributors as ammonia and total organic carbon levels. In this manner, we assessed the role of organic contamination in these systems and the potential effect, if any, relative to the steam purity being recorded.

SUGAR CANE MILL CASE STUDY

This particular mill grinds approximately 10,000 tons of cane/day. The boiler plant consists of four 240 PSI boilers which collectively generate 11,000,000 lbs. of steam daily. The steam in this sugar mill is used both for power generation and for process applications.

Approximately 40% of the boiler make-up comes from condensate returned from the turbines with the balance coming from process condensate. This varies from time to time and, of course, from plant to plant. A typical boiler feedwater analysis during this study was as follows:

*Ammonia	10 - 20 ppm
Hardness	0 - 5 ppm
pH	8.6 - 9.0 units
Sugar	0 - trace
TDS	36 - 42 ppm
*Organic carbon	375 - 465 ppm
*Freon extractables	5 - 10 ppm

*Analysis performed by Central Regional Laboratories of Olin Water Services.

A typical boiler blowdown analysis during this study is as follows:

pH	10.0 - 12.0 units
TDS	1280 - 3200 ppm
Phosphate	40 - 80+ ppm
Sulfite	35 - 80 ppm
Hydrates (BaCl ₂)	360 - 850 ppm
*Organic carbon	900 - 1000 ppm
*Ammonia	1 - 2 ppm
*Freon extractables	30 - 40 ppm

*Analysis performed by Central Regional Laboratories of Olin Water Services.

PAST HISTORY

The boiler-water chemical program in use at the beginning of this steam purity study had been used for approximately 4 years. Throughout this period, intermittent large amounts of carryover were thought to have caused operational problems. One of the serious problems that did develop was the formation of deposits on the stems of the turbine governors. Loss of control and downtime for cleaning resulted because of these deposits. Severe priming was frequently observed ultimately resulting in reduced operating rates until the carryover situation could be corrected.

Over the years, many equipment and chemical program modifications were made but the operational problems were not eliminated.

Our first purpose, therefore, was to identify the boiler(s) which were contributing to this condition. Steam from each boiler was studied along with regular analyses of feedwater, boiler blowdown water and plant operating practices. Table 1 represents some of this base line data.

Table 1. Baseline steam purity study.

Boiler	Total solids in boiler water	Total solids in steam*
A	2,796 ppm	0.69 ppm
B	1,938	1.03
C	1,382	4.30
D	3,418	2.40

*Maximum sustained concentrations.

Most boiler manufacturers guarantee their boilers to produce a steam purity of 1 ppm or less of total solids at given boiler water conditions. This level of steam quality is considered necessary to minimize deposits in superheaters and in steam turbines. Frequently, however, steam turbines require total solids in the steam to be less than 0.6 ppm to obtain satisfactory operating conditions. As can be seen in Table 1, none of the four units met the 0.6 ppm qualification. In boiler C, despite a relatively low level, total solids appeared to be the primary contributor to poor steam quality, followed by boiler D.

NEW PROGRAM

From this base line study, we recommended a new chemical treatment/control program. This new program addressed itself to the apparent need for a more effective antifoam and for a change in various chemical controls including, of course, the boiler waters' dissolved solids level. Mechanical operating parameters were not changed during this phase of the study.

SECOND STUDY PHASE

Another series of steam purity determinations was conducted after the new chemical/control program was operational and the data obtained from that study appears in Table 2.

Table 2. Modified program steam purity study.

Boiler	Total solids in boiler water	Total solids in steam*
A	3,712 ppm	0.79 ppm
B	3,806	0.88
C	2,722	0.89
D**	1,192	1.19

*Maximum sustained concentrations.

**At the time of this study, the D boiler had been placed in service for less than 1 hour. This unit was still concentrating during the test period.

As you can see, the overall steam purity had been substantially improved during the new chemical/control program. This benefit was reinforced by the fact that during this period no priming occurred, and no sticking steam turbine governors or unsatisfactory steam turbine operations were observed. This decrease in steam contamination (base average 2.1 ppm to modified program average 0.94 ppm) took place at the same time that boiler total solids level increased from an average of 2384 ppm during the base period to 2858 ppm during the modified program. Normally carryover will occur more frequently as the level of total solids increases, however, we were able to increase the boiler solids during this study and yet improve the steam quality, thereby reducing continual blowdown requirements. Table 3 summarizes this data.

Table 3. Boiler water solids study: Boiler total solids.

Boiler	Base line	Modified program	% change
A	2796 ppm	3712 ppm	+32.8
B	1938	3806	+96.4
C	1382	2722	+96.9
D*	3418	1192	-65.0
Ave	2384	2858	+19.9

*At the time of this study, the D boiler had been placed in service for less than 1 hour. This unit was still concentrating during the test period.

The information summarized in Table 4 provides a graphic presentation of the steam quality changes which occurred during this period.

Table 4. Steam quality study: Steam total solids.

Boiler	Base line	Modified program	% change
A	0.69 ppm	.79 ppm	(14.5)
B	1.03	.88	14.6
C	4.30	.89	79.3
D	2.40	1.19	50.4
Ave	2.10	0.94	55.2

Based upon the data, one can conclude how in-depth steam purity studies can be used to coordinate and develop the necessary chemical/control program, tailor-made for each individual boiler, based upon its individual characteristics. The new chemical/control program actually reduced the average amount of total solids in the steam to less than half of its previous levels. The range of steam quality improvement, as a result of all conditions observed during the steam study as well as our recommended changes in chemicals and controls, provided improved quality of the steam generated ranging from 15% to nearly 80%.

During this same time, the average total solids level in A, B, and C boilers increased approximately 40%. As a result of this boiler plant now carrying higher concentration levels in the boiler water, significantly less continual blowdown was required, resulting in energy savings.

In addition to the energy savings, steam quality was greatly improved. Lower water and chemical costs were found and improved turbine efficiency/reliability with less plant downtime and/or curtailed production rates was delivered.

This entire paper deals with the results and efficiency that can be effected by the use of an in-depth steam purity study. As pointed out in our introductory comments and as amplified in our October, 1974 paper to the ASSCT Convention in Clewiston, Florida, other great improvements in boiler operating efficiencies can be realized through the use of sodium elution studies, deaerator efficiency studies and fireside treatment studies.

All of these studies are recommended depending on your individual plant operation in order that the optimum operation level of each boiler plant operation in order that the optimum operation level of each boiler plant can be achieved.

DEFINITIONS

Steam purity - The relative amount of total solids entrained in the steam produced by a steam generator.

Carryover - Any material, solid, liquid or gas that leaves the steam drum and travels with the steam.

mg/l - Milligrams per liter.

ml/min - Milliliters per minute.

Na⁺ - Sodium ion

ppb - Parts per billion

ppm - Parts per million

TS - Total solids, a gravimetric determination of both dissolved and suspended solids.

TDS - Total dissolved solids expressed as ppm NaCl equivalent conductivity.

Freon extractable matter - Relatively non-volatile organic compounds such as oils, greases, unsaturated fats, fatty acids and related hydrocarbons.

Organic carbon - The carbon present originating from organic compounds such as hydrocarbons.

PANS' CAPACITY AND BOILING SYSTEM

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INTRODUCTION

This is a study of our pans' capacity, which I bring to your consideration since most of the figures and conclusions apply to any cane sugar house; therefore, I hope you find some useful information in it.

We have not been able to run the pan floor at maximum capacity since we are short in some other departments, but we expect to do so the next crop.

EQUIPMENT

We have five Honiron low head pans, 2000 ft³ capacity, each with automatic vacuum and feed controls: Pan No. 1 with Webre circulator for low grade strikes (C Massc.); Pan No. 2 with Webre circulator and a Fischer and Porter supersaturation indicator to grain by full seeding. (It boils C footings, C strikes if necessary, and commercial sugar strikes too); Pans No. 3, 4 and 5 for commercial sugar strikes and boil footings for these strikes.

BASIC DATA

Material	% cane	Brix	Pol	Pur.	% moist.
Normal juice	76.25	16.5		76.5	
Mix juice	88.5	14.2		76.5	
Syrup		62.0		77.8	
A massecuite		95.0		79.3	
A molasses		60.0		61.0	
B massecuite		97.0		72.3	
B molasses		60.0		59.9	
C massecuite		99.0		60.0	
Final molasses		90.5		38.0	
Magma		90.0		90.0	
Sugar		99.8	98.7	98.9	0.20
Solids losses	0.14				

C sugar 0.35 mm grain size and commercial sugar 1.0 mm grain size.

BOILING SYSTEMS AND SOLIDS AND MATERIALS BALANCE

For the calculations of solids and materials balance, the solids going into the process are based on the average juice analysis that we had before the cane was damaged by the freeze.

$$88.5 \times 14.2 - 0.14 = 12.43$$

Solids % cane to pans floor

Mix J	Brix	Solid
% cane		Loss

Under the same conditions of solids in juice % cane, the same materials through the process, C sugar and commercial sugar grain size, steam, vacuum etc., the pans capacity will depend on the boiling system used. We had been using the A-B-C boiling system or the A-C boiling system. When using the A-B-C boiling system, the graining charge is a blend of 50% syrup and 50% A molasses, about 69 purity and continue the six C footings with A molasses. The C strikes are boiled with B molasses. When using the A-C boiling system, we grain with A molasses and continue the six C footings and C strikes with A molasses also. For these calculations the C massecuite purity will be 61.0 (A molasses purity) instead of 60 purity (A-B-C boiling system, C massecuite purity). Both solids and materials balance are in Tables 1 and 2, and the comparative results are as follows:

Comparative results of the A-B-C and A-C boiling systems at maximum capacity:

	A-B-C system	A-C system
Commercial sugar massc. ft ³	38,000	35,200
" " strikes	19	17.6
" " massc. ft ³ /ton cane	4.02	3.35
" " lb produced	1,539,030	1,711,704
" " strikes water evap. lb/hr	81,716	72,148
C massecuite ft ³	13,056	14,916
C " strikes	6.5	7.5
C " ft ³ /ton cane	1.38	1.42
% magma melt	70.5	77.1
Commercial sugar massc. ft ³ /ton solids	32.34	26.93
Solids to process, tons daily	1,175	1,307
Cane ground, tons daily	9,453	10,513

The figures show an increase in capacity when using the A-C boiling system of 11% more cane ground, 11% more sugar produced, and exhaust steam saving of 12% in this particular case. The increase in capacity and exhaust steam savings is because there are less ft³ of commercial sugar massecuite to produce per ton of solids going into the pan floor and, therefore, per ton of cane.

Table 1. Solids and materials balance in the A-B-C boiling system.

Material	Solids (lb/hr)	Brix	Material (lb/hr)	Ft ³ /hr	Ft ³ /day	Strikes/ day	Ft ³ /ton cane	W. evap (lb/hr)	lb/sugar daily
Syrup	97,917	62	157,931						
Magma	8,173	60	13,622						
Magma	3,420	90	3,800						
Syrup	82,671	62	133,340						
Total	94,264	--	150,762						
A massec	94,264	95	99,226	1049	25,175	12.6	2.66	51,536	
A sugar	45,531	99.8	45,622						1,094,934
A mol (total)	48,733	60	81,222						
A mol (C mas)	16,558	60	27,597						
A mol (B mas)	32,175	60	53,625						
Magma	5,336	60	8,893						
Magma	2,233	90	2,481						
Syrup	10,575	62	17,056						
Total	50,319	--	82,055						
B massec	50,319	97	51,875	538	12,900	6.4	1.36	30,180	
B sugar	18,467	99.8	18,504						444,096
B mol	31,852	60	53,087						
A mol	16,558	60	27,597						
Syrup	4,671	62	7,534						
Total	53,081	--	88,218						
C massec	53,081	99	53,617	544	13,056	6.5	1.38		
Magma	19,162	90	21,291	231					
Final mol	33,919	90.5	37,480						
			Total		38,076	19.0	4.02	81,716	1,539,030
					A & B massc	A & B strike	A & B massc		

Cane ground-9,453 tons daily
Solids to process-1,175 tons daily
Yield (96⁰ Pol sugar)-167.4 lbs per ton cane

In the A-C boiling system the C massecuite ft³ per ton of cane is a little higher due to the higher C massecuite purity. With the same purity that ft³ per ton of cane will be the same for both systems.

The magma melt is higher in the A-C boiling system since there are less ft³ of A massecuite to boil, but, even so, the exhaust steam consumption is lower.

The way the pan floor handles those strikes when boiling at maximum capacity will be:

A-B-C boiling system, pan work time required:

<u>Pan no.</u>	<u>Massc.</u>	<u>Strike/day</u>	<u>Hr/strike</u>	<u>Hr/day</u>	<u>Hr/day (Total/pan)</u>
1	C	6.5	3.75	24	24
2	Graining	1	6	6	
2	3 double	3	2.5	8	
2	C footings				24
2	B	3	3.25	10	
3	B	3.4	3.25	11	
3	A	5.2	2.5	13	24
4	A	7.4	2.5	18.5	
4	A-B footings	-	2.2	5.5	24
5	A-B footings	-	2.2	24	24
A strikes 12.6					
B strikes 6.4					
C strikes 6.5 (from solids and materials balance)					

NOTE: The time per strikes is from steam on to steam on

A-C boiling system, pan work times required:

<u>Pan no.</u>	<u>Massc.</u>	<u>Strike/day</u>	<u>Hr/strike</u>	<u>Hr/day</u>	<u>Hr/day (Total/pan)</u>
1	C	6.5	3.75	24	24
2	C	1	3.75	3.75	
2	Graining	1.25	7	9	23
2	3.75 double	3.75	2.75	10.3	
2	C footings				
3	A	9.6	2.5	24	24
4	A	8	2.5	20	23.5
4	A footings	-	2.2	3.5	
5	A footings	-	2.2	24	24

Table 2. Solids and materials balance in the A-C boiling system.

<u>Material</u>	<u>Solids (lb/hr)</u>	<u>Brix</u>	<u>Material (lb/hr)</u>	<u>Ft³/hr</u>	<u>Ft³/day</u>	<u>Strikes/ day</u>	<u>Ft³/ton cane</u>	<u>W. evap (lb/hr)</u>	<u>lb/sugar</u>
Syrup	108,901	62	175,647						
Magma	17,632	60	29,387						
Magma	5,237	90	5,819						
Syrup	108,901	62	175,647						
Total	131,770	--	210,853						
A massc	131,770	95	138,705	1,467	35,200	17.6	3.35	72,148	
A sugar	71,178	99.8	71,321						1,711,704
A mol	60,592	60	100,987						
C massc	60,592	99	61,204	621	14,916	7.5	1.42		
Magma	22,869	90	25,410	275					
Final mol	37,723	90.5	41,683						

Cane ground -10,513 tons daily

Solids to process -1,307 tons daily

Yield (96° Pol sugar) -167.4 lbs per ton cane

COMMENTS

The A-B-C boiling system allows for the boiling of 19 A and B strikes due to the fact that grinding less cane there are only 6.5 C strikes, leaving spare time for Pan No. 2 to boil commercial sugar strikes, while the A-C boiling system will have time to boil only 17.6 A strikes since grinding more cane will produce more C strikes (about 7.5) and Pan No. 2 will be busy boiling the extra C strikes and the extra C footings needed; it has to grain more often also, and the time for graining will be longer due to lower purity of the graining charge.

Ft³ of commercial sugar massecuite per ft³ of magma:

$$1.0 \text{ mm commercial} \div 0.35 \text{ mm C sugar} = 2.857 \text{ development (grain)}$$

$$(2.857)^3 = 23.32 \text{ ft}^3 \text{ commercial sugar massecuite per ft}^3 \text{ magma}$$

So, 850 ft³ magma footing x 23.32 = 19,900 ft³ commercial sugar massc. (10 strikes.)

I would like to point out that due to the extra pan capacity during the last two crops we boiled between 14 and 16 strikes out of one magma footing, producing commercial sugar between 1.10 mm and 1.20 mm.

Grain size development without melting magma (A-B-C boiling system):

A and B massc.	1,487 ft ³ /hr
Magma	231 ft ³ /hr

$$1,587 \div 231 = 6.87 \text{ ft}^3 \text{ A and B massc. per ft}^3 \text{ magma.}$$

$$\sqrt[3]{6.87} = 1.9 \text{ increase in grain size without melting magma.}$$

0.35 mm x 1.9 = 0.67 mm A and B sugar grain size without melting magma. (grain too small for commercial sugar)

Magma melt to produce 1.0 mm grain size sugar (A-B-C boiling system):

$$6.87 \div 23.32\% = 29.5\% \text{ magma used}$$

$$70.5\% \text{ magma melt}$$

NOTE: In the same way the A-C boiling system will melt 77% magma

Extra water evaporated melting magma (A-B-C boiling system): When melting 70.5% magma, the extra water to be evaporated by the A and B pans will be 7,505 lb/hr or 10% more and consequently more time too.

<u>Material</u>	<u>Solid</u> <u>(lb/hr)</u>	<u>Brix</u>	<u>Material</u> <u>(lb/hr)</u>	<u>W. evap</u> <u>(lb/hr)</u>
Magma	11,593	90	12,881	
Syrup	82,671	62	133,340	
Total	94,264	--	146,221	
A massc.	94,264	95	99,226	46,995
A mol	32,175	60	53,625	
Magma	7,569	90	8,410	
Syrup	10,575	62	17,056	
Total	50,319	--	79,091	
B massc.	50,319	97	51,875	27,216
			TOTAL:	74,211

Water evap. lb/hr melting 70.5% magma: 81,716

Water evap. lb/hr not melting magma: 74,211

Difference: 7,505 lb/hr (10% increase)

CONCLUSIONS

1. Producing bigger commercial sugar grain reduces the capacity.
2. Producing higher pol sugar decreases the capacity since there is more boil back of A and B molasses, and lower retention also.
3. The A-C boiling system increases the capacity compared to the A-B-C boiling system.
4. The most important conclusion is the effect on solids in juice % cane. If it goes up because of N.J. % cane or N.J. brix increase, the capacity comes down (Cane that a sugar mill is able to grind). What we handle in our boiling house are solids; therefore, the solids going into the process in pounds per hour or tons per day are very important, and this is the real boiling house capacity under the same conditions for a sugar mill. I don't know of any sugar mill that reports it, therefore, before I finish I would like to suggest to the members of this Society to start reporting this figure in their Daily Reports. I hope that in getting more familiar with it you will find it to be a useful information.

INFLUENCE OF FENAC AND TERBACIL ON GROWTH AND YIELD OF SUGARCANE

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ABSTRACT

The tolerance of sugarcane to (2,3,6-trichlorophenyl)acetic acid (fenac) and 3-tert-butyl-5-chloro-6-methyluracil (terbacil) was measured in field plots as a function of herbicide concentration and time of application. Tolerance was estimated primarily from a comparison of yield of treated and hand-weeded plots. Herbicide dosages commonly used for weed control in autumn or spring, fenac at 4 lb/A and terbacil at 2 to 3 lb/A, did not substantially depress yield of planted sugarcane on Sharkey clay or silt loam soils. When applied at about twice the normal rate, both herbicides depressed yield of planted sugarcane, but yield was reduced with fenac only on Sharkey clay and terbacil depressed yield only on silt loam. When both planted sugarcane and its two ratoons were sprayed with fenac at 4.5 lb/A or terbacil at 1.6 lb/A, yield in the planted crop was higher with terbacil than with fenac, but ratoon yields were about equal for both herbicides.

INTRODUCTION

The herbicides (2,3,6-trichlorophenyl)acetic acid (fenac) and 3-tert-butyl-5-chloro-6-methyluracil (terbacil) are widely used in Louisiana sugarcane for residual preemergence control of seedling weeds, especially johnsongrass (*Sorghum halepense* (L.) Pers.). Sugarcane seems to tolerate these herbicides reasonably well, but injury is observed occasionally. Roots of sugarcane are stunted by high concentrations of fenac in the root zone (2). Terbacil applied to medium-textured soil has occasionally caused chlorosis of sugarcane, particularly on cultivar CP 48-103.

Most sugarcane cultivars now grown in Louisiana, other than CP 48-103, seem about equally tolerant to fenac and terbacil applied singly. The cultivars CP 44-101, CP 52-68, and NCo 310 have not responded differentially to fenac at 6 or 12 lb/A (3), and the cultivars CP 52-68 and L 60-25 have not responded differentially to either fenac at 4.5 lb/A or terbacil at 1.6 lb/A (1).

The work reported here is a compilation of several experiments designed to determine the tolerance of sugarcane to various concentrations of these herbicides when applied to typical fine-textured and medium-textured soil found in southern Louisiana.

MATERIALS AND METHODS

In six field experiments near Houma and Lockport, Louisiana during 1962-1968, we evaluated fenac and terbacil treatments either in separate experiments or in the same experiment. Commercial formulations of the herbicides were applied either after planting in autumn or during the following March or April. Herbicides applied in autumn were reapplied the following spring. In some experiments, herbicides were reapplied to the ratoon crop. With a tractor-mounted sprayer, we directed water-herbicide sprays to soil in a 24-inch or 36-inch band over the top of the sugarcane bed; in the spring the many emerged sugarcane plants were also partially wet by the sprays. Plots, 3 rows x 45 feet long, were maintained relatively free of weeds by cultivating and by hoeing. Winter weeds usually were removed in early March before herbicides were applied to soil, and other weeds were then removed periodically during spring and summer.

Experiment 1. A 5 x 5 factorial experiment arranged in a split-plot design with four replications was conducted on Sharkey clay. Whole plots were five concentrations (0 to 8 lb/A) of fenac applied to CP 44-101 sugarcane in autumn 1962 and subplots were the same five concentrations applied the following spring.

Experiment 2. Five concentrations (0 to 8 lb/A) of fenac were applied in one field to CP 44-101 sugarcane on Commerce silt loam. The same concentrations were also applied in an adjacent field to CP 52-68 sugarcane on Sharkey clay. Treatments were applied in spring 1963 to planted cane and reapplied the following spring to the ratoon. The experimental design was a randomized complete block with 16 replications. A few replications were eliminated in the ratoon because of poor stands.

^{1/}Research at this location is in cooperation with the Louisiana Agricultural Experiment Station.

Experiment 3. Fenac at 6 or 8 lb/A and terbacil at 2 or 4 lb/A were applied in the spring of 1965 to CP 52-68 sugarcane on Sharkey clay. The experimental design was a randomized complete block with five replications. The winds and rain of Hurricane Betsy damaged the plantings of this experiment in September 1965, and we evaluated lodging one month later by counting the clumps of sugarcane that were uprooted. A clump was considered uprooted if an estimated 25% or more of the root system in a clump was visible.

Experiment 4. A 5 x 5 factorial experiment arranged in a split-plot design with four replications was conducted on Commerce silt loam. Whole plots were five concentrations (0 to 6 lb/A) of terbacil applied to CP 52-68 sugarcane in autumn 1964 and subplots were the same five concentrations applied the following spring.

Experiment 5. Four concentrations (1.2 to 4.8 lb/A) of terbacil were applied to CP 52-68 sugarcane on silt loam in autumn 1964 and reapplied the following spring. The experimental design was a randomized complete block with five replications.

Experiment 6. Fenac at 4.5 lb/A, terbacil at 1.6 lb/A, and a less residual standard-practice treatment were applied to CP 55-30 sugarcane on Mhoon silty clay loam in autumn 1965 and reapplied each spring during the following 3 years. For the standard-practice treatment we applied a mixture of the sodium salt of trichloroacetic acid (TCA) at 10 lb/A and 2-(2,4,5-trichlorophenoxy)propionic acid (silvex) at 3 lb/A in autumn and again in early spring; this was followed by fenac at 4.5 lb/A later in spring and a mixture of TCA at 17.6 lb/A and silvex at 3 lb/A each spring in the ratoon crops. The experimental design was a randomized complete block with 7 replications.

We obtained yields from each of the six experiments during the regular autumn-winter harvest period. In Experiments 1 to 5 we used yield of cane per acre as the quantitative measure of herbicidal injury; the untreated check was the standard for determining significant deviations in yield. In Experiment 6 we used millable stalk counts and yield of cane and sugar as a measure of the vigor of sugarcane growing under the different herbicide treatments.

RESULTS AND DISCUSSION

A statistical analysis of Experiment 1 showed that the various combinations of autumn and spring fenac treatments on Sharkey clay affected yield of sugarcane only in an additive manner, i.e., no interaction occurred. Consequently, the mean yields from autumn and from spring treatments can be considered separately (Table 1). In autumn, 8 lb/A of fenac reduced yield about 20% below the untreated check, whereas 2 to 6 lb/A did not significantly affect yield. In spring, 4 to 8 lb/A reduced yield by about 5 to 8%. The large yield reduction caused by 8 lb/A in autumn is in sharp contrast to the results of an earlier experiment on Commerce silt loam in which 8 lb/A applied both in autumn and spring did not reduce yield significantly (2).

Table 1. Effect of fenac applications in autumn and spring on yield of planted sugarcane (CP 44-101) on Sharkey clay (Experiment 1).

Rate of fenac in spring (lb/A)	Tons cane/acre ^{1/} Rate of fenac in autumn (lb/A)					Mean
	0	2	4	6	8	
0	39	38	38	37	31	36 c
2	38	39	34	36	29	35 bc
4	38	36	37	34	28	34 ab
6	35	36	35	34	28	34 ab
8	35	36	34	33	28	33 a
Mean	37 b	37 b	35 b	35 b	29 a	

^{1/}Significant differences are shown only for mean values because no significant interaction occurred between autumn and spring treatments. Means in a column or in a row followed by the same letter are not significantly different at the 5% level of probability as determined by the Duncan multiple range test.

The two separate field experiments in Experiment 2 provide an indirect comparison of the phytotoxicity of fenac on the two soil types (Table 2). Fenac at 6 or 8 lb/A applied in spring significantly reduced yield of planted and ratoon crops of CP 52-68 sugarcane on Sharkey clay

but did not significantly reduce yield of the two crops of CP 44-101 sugarcane on Commerce silt loam. A dosage of 2 or 4 lb/A did not significantly reduce yield on either soil type. The different cultivars in each field introduced an additional variable in this experiment, but CP 44-101 and CP 52-68 are about equally tolerant to fenac (3). The lower yields in the ratoon compared to the planted crop evidently were caused by damage to the ratoon cane by harvesting under muddy conditions and by water standing in the ruts for long periods following heavy winter rains.

Table 2. Yield of sugarcane on two soil types as affected by fenac applied in spring to planted sugarcane (1st crop) and reapplied the following spring to the ratoon (2nd crop) (Experiment 2)

Rate of fenac/ application (lb/A)	Tons cane/acre ^{1/}			
	Commerce silt loam ^{2/}		Sharkey clay ^{3/}	
	1st crop	2nd crop	1st crop	2nd crop
0	38 a	31 a	38 b	21 cd
2	38 a	31 a	38 b	22 d
4	37 a	31 a	38 b	20 bc
6	37 a	30 a	36 a	19 ab
8	36 a	30 a	35 a	18 a

On Sharkey clay in Experiment 3, fenac at 6 or 8 lb/A was more phytotoxic to sugarcane and caused more lodging of sugarcane during Hurricane Betsy than was terbacil at 2 or 4 lb/A or the untreated check (Table 3). Sugarcane treated with fenac had many stubby roots, and the weaker root system evidently increased the tendency to lodge.

Table 3. Effect of spring applications of terbacil and fenac on yield of planted sugarcane (CP 52-68) on Sharkey clay and on lodging of sugarcane during Hurricane Betsy (Experiment 3)

Herbicide & rate (lb/A)	Tons cane/acre ^{1/}	Clumps uprooted/ acre ^{1/}
None	26 bc	341 b
Terbacil - 2	29 c	305 b
Terbacil - 4	29 c	276 b
Fenac - 6	23 b	473 a
Fenac - 8	19 a	473 a

^{1/}Figures in each column followed by the same letter are not significantly different at the 5% level of probability as determined by the Duncan multiple range test.

The tolerance of sugarcane to fenac on Sharkey clay was influenced primarily by dosage. Fenac generally was not excessively phytotoxic to sugarcane at dosages needed for weed control--4 lb/A applied both in autumn and spring or 4 to 6 lb/A applied only in spring--but was phytotoxic at about twice these dosages.

Several factors may be responsible for the increased phytotoxicity of fenac on Sharkey clay. In greenhouse experiments with snap beans (*Phaseolus vulgaris* L.), Sheets et al. (5) found that fenac was more phytotoxic on Sharkey clay than on four loam soils and that the phytotoxicity increased as clay and organic matter increased among the five soils. Typically, in our studies, Sharkey clay and Commerce silt loam had about 3.1% and 1.6% organic matter, respectively (4). Also, the Sharkey clay and related soils in southern Louisiana occur at low elevations and natural drainage, both runoff of water and internal drainage, usually is slow. Under these conditions, any injury to roots by fenac could be compounded by the poorly aerated soil. Silt loam soils generally occur at higher elevations and are better drained.

No interaction was found between autumn and spring terbacil treatments on Commerce silt loam in Experiment 4 (Table 4). Yields from the untreated check and other treatments that received no terbacil in autumn were generally lower than treatments that received 1 or 2 lb/A in autumn. Weeds may have caused the lower yields by competing with sugarcane before removal, or these concentrations of terbacil may have stimulated growth of sugarcane. When mean values are considered, autumn treatments at 1 to 6 lb/A did not injure sugarcane or reduce yield. In spring, 1 to 3 lb/A also did not affect yield but 6 lb/A caused chlorosis and reduced yield moderately.

Table 4. Effect of terbacil applications in autumn and spring on injury and yield of planted sugarcane (CP 52-68) on Commerce silt loam (Experiment 4).

Rate of terbacil in spring (lb/A)	Tons cane/acre ^{1/}					Mean
	Rate of terbacil in autumn (lb/A)					
	0	1	2	3	6	
0	23	26	28	24	26	25 b
1	23	27	28	27	27	26 b
2	25	27	28	25	25	26 b
3	26	26	27	24	26	26 b
6	22 ^{2/}	23 ^{2/}	26 ^{3/}	22 ^{4/}	23 ^{4/}	23 a
Mean	24 a	26 a	28 a	24 a	25 a	

^{1/}Significant differences are shown only for mean values because no significant interaction occurred between autumn and spring treatments. Means in a column or in a row followed by the same letter are not significantly different at the 5% level of probability as determined by the Duncan multiple range test.

^{2/}Had an injury rating of 3 on a 0-10 scale.

^{3/}Had an injury rating of 2 on a 0-10 scale.

^{4/}Had an injury rating of 4 on a 0-10 scale.

Yield of sugarcane in Experiment 5 on silt loam closely followed the dosage of terbacil in autumn and spring (Table 5). Yield decreased as the dosage increased from 1.2 to 4.8 lb/A, but only the 4.8 lb/A treatment injured sugarcane visibly and significantly reduced yield below the untreated check.

Table 5. Effect of terbacil concentration when applied in autumn and spring on injury and yield of planted sugarcane (CP 52-68) on silt loam (Experiment 5).

Herbicide & rate/ application (lb/A)	Tons cane/acre ^{2/}	Injury rating ^{1/} (0-10)
None	29 bc	0
Terbacil - 1.2	31 c	0
Terbacil - 2.4	30 bc	0
Terbacil - 3.6	27 b	0
Terbacil - 4.8	24 a	4
Fenac - 4.3	30 bc	0

^{1/}0 = no injury; 10 = all plants killed.

^{2/}Yields followed by the same letter are not significantly different at the 5% level of probability as determined by the Duncan multiple range test.

On Sharkey clay, Experiment 3, a spring application of terbacil at 4 lb/A produced exceptionally high yields when compared to the untreated check and to fenac treatments (Table 3).

Terbacil controls weeds when applied at 1.6 lb/A in both autumn and spring or at about 3.2 lb/A in spring only. These dosages are within the range of dosages found relatively nonphytotoxic to sugarcane in these experiments.

The average annual yield for sugarcane treated repeatedly with terbacil, fenac, or a standard-practice check in Experiment 6 was 34, 33, and 32 tons cane per acre, respectively (Table 6). The yield of sugar per ton of cane was not affected by herbicide treatment. In planted cane, sugarcane treated with terbacil had more stalks and a higher yield of cane and sugar per acre than the other treatments. In the first and second ratoons, all treatments affected growth and yield about equally. Similar results were found in another experiment on Mhoon silty clay loam (1).

Table 6. Effect of four annual applications of terbacil and fenac on stalk population and yield of a three-year crop of sugarcane (CP 55-30) on Mhoon silty clay loam (Experiment 6).

Herbicide & rate/ application (lb/A)	Planted cane	First ratoon	Second ratoon	Mean
Tons cane/acre ^{3/}				
Terbacil - 1,6 ^{1/}	34 c	37 a	32 a	34
Fenac - 4.5 ^{1/}	30 b	37 a	31 a	33
Standard practice ^{2/}	30 b	36 a	30 a	32
Lb sugar/ton of cane ^{3/}				
Terbacil - 1,6 ^{1/}	178 a	238 a	197 a	204
Fenac - 4.5 ^{1/}	180 a	224 a	194 a	199
Standard practice ^{2/}	177 a	222 a	196 a	198
Lb sugar/acre ^{3/}				
Terbacil - 1,6 ^{1/}	5,990 c	8,830 b	6,240 a	7,020
Fenac - 4.5 ^{1/}	5,390 b	8,310 a	6,010 a	6,570
Standard practice ^{2/}	5,300 b	7,940 a	5,930 a	6,390
No. of stalks/acre in Sept (thousands) ^{3/}				
Terbacil - 1,6 ^{1/}	29.6 b	38.7 a	37.4 a	35.2
Fenac - 4.5 ^{1/}	27.8 a	38.0 a	37.0 a	34.2
Standard practice ^{2/}	27.9 a	37.5 a	36.4 a	34.0

^{1/}Herbicide applied in autumn and spring on planted cane and reapplied each spring to the first and second ratoons.

^{2/}TCA-10 lb/A + silvex - 3 lb/A applied in autumn and in early spring to planted cane; fenac - 4.5 lb/A applied in late spring to planted cane; TCA - 17.6 lb/A + silvex - 3 lb/A applied in spring to both the first and second ratoons.

^{3/}Figures in each column followed by the same letter are not significantly different at the 5% level of probability as determined by the Duncan multiple range test.

The higher yield in the planted crop that seems to occur frequently with terbacil as compared to fenac may be caused by injury from fenac, by a stimulation of growth by terbacil, or a combination of both factors.

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FACTORS AFFECTING THE EXPRESSION OF JUVENILE SYMPTOMS OF
THE RATOON STUNTING DISEASE^{1/}

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ABSTRACT

The juvenile symptom of the ratoon stunting disease of sugarcane, typically a salmon color in the internal stem tissue of the young plant, is shown more consistently by CP 44-101 than any other variety tested. Primary shoots from greenhouse-grown cuttings planted in vermiculite are used to assay for ratoon stunting disease. Variation in the intensity of the juvenile symptom led to an investigation of the factors involved. The salmon color was stronger in young plants fertilized weekly with ammonium nitrate or with complete fertilizer than in unfertilized plants. Light intensity affected symptom expression; shade produced stronger symptoms. Plants grown without shade and fertilizer had poorly developed symptoms. There was no difference in symptom expression between plants grown from inoculated cuttings or from plants infected with the disease. Bud position at time of planting had no effect on symptom development. Large seed pieces (40 cm) gave weak symptoms; small seed pieces (3 cm) gave strong symptoms. Symptoms were apparent on 57% of fertilized, shaded plants 19 days after planting. Frequency and intensity increased rapidly and 100% expression was reached in 43 days. Frequency and intensity of symptoms diminished after 50 days.

INTRODUCTION

Widely recognized as the most serious disease of sugarcane, ratoon stunting disease (RSD) has always been difficult to diagnose. There are no external symptoms on sugarcane (Saccharum hybrids) and only a sudan hybrid (Sorghum sudanese) under special conditions has shown an external symptom (1) other than growth depression.

The classic symptom of RSD is a discoloration of vascular bundles and leaf traces at the base of the mature stalk. Tangential slices of the lower stalk reveal a series of red to black dots just below the nodal plate. These symptoms may disappear in standing cane or fade in cut specimens. Absence of the symptom is no proof of absence of the disease. Mature stalk symptoms may be present in the variety US 58-4 when the disease is apparently absent.^{2/} Mature symptoms of RSD may be confused with the internal symptoms of gumming disease, chlorotic streak, or leaf scald; symptoms of fusarium stem rot, red rot or borer damage may obscure mature symptoms of RSD (5). The time required for the development of mature symptoms may be from 3 to 8 months.

The juvenile symptom appears as a salmon discoloration of the developing parenchyma just below the terminal meristem. Some sugarcane varieties do not produce the discoloration, others have a background color which interferes with the diagnosis of RSD. In New South Wales, some plants infected with leaf scald produce a salmon discoloration similar to the RSD symptom (5).

The variety CP 44-101 has been used for 15 years at this laboratory as a standard assay plant for RSD diagnosis because of the clarity of the juvenile symptoms. It has been used extensively as an RSD assay plant in heat-treatment studies here (2) and for purification studies here and at Beltsville, Md. (3,4). Workers at other locations have not been uniformly successful. Dean^{2/} was unable to produce satisfactory symptoms at either Meridian, Mississippi, or Canal Point, Florida. Correspondence with workers in Tanzania indicates total failure and those in South Africa report only partial success.

Because of the difference in response reported by others, and because of variable results at this location, a series of tests was initiated to identify sources of variations with the goal of standardizing test procedures.

^{1/} Research at this location is done in cooperation with the Louisiana Agricultural Experiment Station.

^{2/} Dr. Jack Dean, Canal Point, Florida, Personal Communication.

MATERIALS AND METHODS

All plants used in this test were grown in vermiculite in galvanized iron flats measuring 50 cm X 35 cm X 9.5 cm. The flats were painted with static asphalt. A layer of steam-sterilized vermiculite was spread in the flat to a depth of 6 cm. Seed pieces were pressed into the substrate and were generally arranged with the buds up. The seed pieces were covered with vermiculite so that buds had a minimum of a 1 cm cover. Watering was done as needed. All experiments were conducted throughout the year in greenhouses; temperatures varied from 18 to 49 C.

Experiment No. 1 was designed to determine variety differences in response to the juvenile symptom of RSD. Fourteen varieties were included in the test, with 4 replications of 5 seed pieces in each variety. The varieties were CP 44-101, CP 48-103, CP 52-68, CP 55-30, CP 60-16, CP 61-37, CP 62-250, CP 62-258, L 60-25, L 61-43, L 61-67, L 62-86, L 62-96, and NCo 310. Cane from each variety was progeny of hot-water treated (2 hr 50 C) cane, and single bud pieces were planted as healthy checks (20 plants per variety). Similarly, 20 single bud pieces of each variety were inoculated with the ratoon stunting disease agent by dipping the freshly cut ends in juice from RSD-infected stalks of CP 44-101. Healthy checks were planted first and inoculated seed pieces were planted after the inoculum dried. Plants were assayed for the RSD juvenile symptom 6 weeks after planting. Additional plants of RSD-infected CP 44-101, CP 55-30, CP 61-37, L 61-43, L 61-67, and NCo 310 were grown for 3 months, and were then harvested. Juice of each variety was used to inoculate healthy seed pieces of CP 44-101. Plants from these cuttings were observed for juvenile symptoms 6 weeks after planting in vermiculite.

Experiment No. 2 was a split, split plot design with 4 replications, 18 treatments and 20 observations per plot. Main plot treatments were light intensity levels, with incident light reduced by placing white gauze screens over the plants. Full light intensity in the greenhouse was used as one treatment and gauze screens reduced this to 50 and 25% in two additional treatments. Sub-plot treatments were a) cane of the variety CP 44-101 which had never been heat-treated and was previously infected, or, b) progeny of hot-water treated cane inoculated with juice from infected cane by dipping freshly cut ends. Sub-sub-plots were 3 fertilizer treatment receiving no fertilizer, one receiving nitrogen as ammonium nitrate at a rate of 1.71 g/M² in 6 weeks, and one receiving a complete fertilizer with minor elements at an equivalent rate of N. Seed pieces (7 cm) were planted in vermiculite, and treatments were imposed and observations of the juvenile symptom of RSD were made after 5 weeks. These symptoms were rated from 0 to 6, with 0 being negative and 6 very strong.

Experiment No. 3 was a randomized block experiment designed to test the effect of levels of N on symptom expression in CP 44-101. Six levels of N were replicated 4 times with 20 observations per plot. Nitrogen as ammonium nitrate was added at 0.86 g, 1.71 g, 3.43 g, 6.86 g, and 13.71 g/M². Applications were split over 4 weeks with 25% of the fertilizer applied weekly as a liquid. The plants from 7 cm seed pieces were grown under 17% of full light intensity for 6 weeks before observations for juvenile RSD symptoms were made.

Experiment No. 4 was designed to determine the effect of seed piece size on symptom expression in CP 44-101. Seed pieces were 3, 7, 15, 30, and 40 cm in length. Seed pieces from 3 to 15 cm had one node; pieces 30 cm had 2 nodes, and 40 cm pieces had 3 nodes. Only one bud was left intact, and the other buds were cut out. After six weeks under 25% full light intensity, measurements were made of height to the newest visible dewlap and observations were made of juvenile RSD symptoms. Ten replications with two observations per replication were used. The experiment was partially repeated, using 3 and 40 cm pieces and observing symptoms at 4 weeks after planting.

Experiment No. 5 was designed to test the effect of the position of the bud at planting on the expression of the juvenile symptom. Seed pieces of CP 44-101, 7 cm long, were placed in flats of vermiculite and the buds were arranged up, down, or the right or left. Each position treatment was replicated four times with five plants per plot. Height to the youngest visible dewlap and symptom expression were recorded six weeks after planting.

RESULTS AND DISCUSSION

The juvenile symptoms in CP 44-101 in Experiment No. 1 were the typical salmon pink and all diseased plants exhibited the symptoms. Healthy plants had a pale ivory color in the young internal stem tissue. The varieties CP 52-68, CP 60-16, and L 60-25 also had salmon pink stem tissue in diseased plants but symptom frequency varied from 5 to 50%. Other varieties tested either developed no color in response to inoculation, or the color produced in healthy plants could have obscured symptom production. That varieties which were inoculated and did not produce symptoms were infected with RSD was demonstrated when juice from these symptomless varieties was used as inoculum on healthy cuttings of CP 44-101, and abundant symptoms were produced.

Symptom production in Experiment No. 2 showed that plants grown in full sun with no fertilizer produced the poorest symptoms (Table 1). Plants given complete fertilizer or nitrogen alone gave much better symptoms than those not receiving fertilizer. Reducing the light intensity to 50% or 25% of full sun enhanced symptom formation. Infected seed pieces and inoculated seed pieces were not significantly different in symptom expression. Interactions were not significant.

Table 1. Effects of fertilizer, light intensity and infection source on juvenile symptoms of RSD in CP 44-101.

Treatment	Symptom intensity ^{1/}	Positive symptoms (%)
<u>Full sun</u>		
Infected		
No fertilizer	0.8	52
Nitrogen	1.5	47
Complete	1.1	55
Inoculated		
No fertilizer	1.1	24
Nitrogen	1.6	50
Complete	1.7	32
<u>50% of full sun</u>		
Infected		
No fertilizer	1.5	49
Nitrogen	2.7	56
Complete	2.9	74
Inoculated		
No fertilizer	1.3	40
Nitrogen	3.1	73
Complete	3.3	69
<u>25% of full sun</u>		
Infected		
No fertilizer	0.6	33
Nitrogen	3.3	76
Complete	3.5	60
Inoculated		
No fertilizer	1.0	18
Nitrogen	3.2	76
Complete	2.9	82
LSD	0.5	21

^{1/0} - negative; 6 - very strong

The data from Table 1 indicate that no advantage in diagnosis is gained by using complete fertilizer, and that nitrogen alone is capable of intensifying the juvenile symptom. To confirm this observation and to determine if N levels affected symptom expression, Experiment No. 3 was conducted with no nitrogen as a control and with 5 levels of N, each level double the next lower level. Data in Table 2 show that symptom intensity increased up to 1.71 g/M² of N for the test period. Doubling this amount produced borderline significance and further increases in N had no effect.

The effects of seed piece size on symptom expression in CP 44-101 can be seen in Table 3. Plants from seed pieces 40 cm long produced the weakest symptoms and the mean intensity rating was significantly lower than that for all other treatments. Symptoms in plants from seed piece lengths of 30 and 15 cm were different from those from other lengths, but were not different from each other. Plants from the smaller lengths, 7 and 3 cm, produced the most intense symptoms and were significantly more intense than other treatments, but did not differ from each other. Table 3 shows that as symptom intensity increased, seed piece length and plant height decreased. When the experiment was repeated using 40 cm and 3 cm seed pieces, but with observations at 4 weeks rather than 6, plants from the large seed pieces showed more intense symptoms. This suggests

that symptoms do appear in plants from large seed pieces, but fade or disappear much earlier than is the case with smaller, less vigorous plants.

Table 2. Effects of levels of ammonium nitrate on symptom expression in CP 44-101.

Treatment	Symptom intensity ^{1/}	Positive symptoms (%)
Nitrogen in g/M ²		
0	2.1	65
0.86	2.4	94
1.71	2.9	98
3.43	3.6	83
6.86	3.9	75
13.71	4.0	98
LSD	0.68	25

^{1/}0 - negative; 6 - very strong

Table 3. Effect of seed piece size on height, CP 44-101, 6 weeks.

Size	Dewlap height (cm)	Terminal bud height (cm)	Symptom intensity ^{1/}	Positive symptoms (%)
40 cm, 3 node	43	7.8	0.3	7
30 cm, 2 node	39	5.8	1.9	64
15 cm, 1 node	25	2.2	2.2	100
7 cm, 1 node	19	1.2	4.3	100
3 cm, 1 node	18	0.9	4.7	100
LSD	1.3	1.1	1.3	18

^{1/}0 - negative; 6 - very strong

Data in Table 4 show that bud position at planting had no effect on symptom expression. Weekly observations of juvenile symptoms showed 57% of the plants with positive symptoms 19 days after planting, and all showed symptoms 5 to 6 weeks after planting. Symptoms faded and the frequency of symptoms dropped after 50 days.

Table 4. Effects of bud position on height and RSD symptom expression in 6 week old plants, CP 44-101.

Position	Height (cm)	Symptom intensity ^{1/}	Positive symptoms (%)
Up	24.4	4.9	95
Down	19.2	4.1	89
Right	22.4	4.5	100
Left	22.5	4.3	95
LSD	3.6	NS	NS

^{1/}0 - negative; 6 - very strong

These results indicate that plants from small seed pieces of the variety CP 44-101, will, when fertilized and shaded, consistently produce typical juvenile symptoms of RSD. That the expression of juvenile symptoms may indicate concentration of the disease agent is indicated by previous work (3, 6).

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THE EFFECT OF HOT WATER AND FUNGICIDE TREATMENTS
ON GERMINATION OF SEEDPIECES USED IN
REPLANTING SUGARCANE FIELDS IN FLORIDA

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ABSTRACT

In a fungicide screening trial, 12 compounds were evaluated for their effectiveness in reducing the time required for sugarcane seedpieces to germinate. Based on the results of this trial, Tersan 75 (Tetramethylthiuramdisulfide) was selected for further study. A combination treatment of hot water immersion (52 C for 20 minutes) and Tersan 75 dip (10,000 ppm ai for 2 minutes) significantly increased emergence over untreated seedpieces. Two replant trials were established in commercial sugarcane fields that produced 48 and 41 tons of cane the previous crop. Treatments consisted of hot water immersion (52 C for 20 minutes) and hot water immersion followed by a 2 minute dip in a suspension of Tersan 75 (12,000 ppm ai). Increases in tons of cane and sugar per acre over the control (untreated seedpieces) were 7.4 and 0.86, respectively, in the 48 ton field (good stand), and 17.8 and 2.24, respectively, in the 41 ton field (moderate stand). In a later trial Difolatan (cis-N- $\overline{[1,1,2,2\text{-tetrachloroethyl}]}$ thio-7-4-cyclohexene-1,2-dicarboximide) combined with the hot water treatment significantly increased emergence over both the untreated seedpieces and seedpieces treated with hot water only.

INTRODUCTION

Considerable effort is being made to increase the number of profitable sugarcane stubble crops due to the increasing costs involved in establishing plant cane. Cultural practices that help maintain a good stand as long as possible are obviously a first consideration. However, in most cases, stands become thinned by numerous skips after one or more stubble crops. Nickell (7) in Hawaii felt that transplanting pregerminated sugarcane has great potential in intensive utilization of land. He stated that studies were underway using pregerminated sugarcane for replanting in ratoon fields. This could be a good approach in certain sugarcane-producing areas. Brandes and Klaphaak (2) recognized the stimulating influence of hot water treatment on germination in 1923. They found that immersion of cuttings for 20 minutes in water at 52 C resulted in rapid germination of buds. Martin and Conant (5) reported similar effects of hot water treatment on germination in their studies in Hawaii. Evans and Wiehe (4) showed that soaking cuttings in a saturated solution of lime resulted in an absorption of 50% more moisture than cuttings soaked in pure water. They felt that hydration of the tissue increased the concentration of reducing sugars which stimulate germination and growth. McMartin (6) observed the stimulating effect of fungicides on germination of sugarcane in South Africa. The stimulating effect of organo-mercurial compounds on germination has been corroborated by Evans and Wiehe (4) in Mauritius, Chi (3) in Formosa and Martin and Wismer (1) in Hawaii. Wismer (8) demonstrated that hot water treatment with phenyl mercuric acetate is effective in controlling pineapple disease and in hastening emergence. He found that soaking cuttings at 50 C for 30 minutes or 52 C for 20 minutes is generally satisfactory for most varieties.

Rapid seedpiece germination is essential when replanting stubble cane fields. If germination is slow, the new plants have a difficult time competing with the well-established stools and little or no improvement in stand is obtained. This research was conducted to determine if treating seedpieces with hot water, a non-mercurial fungicide, or both would accelerate emergence.

MATERIALS AND METHODS

Fungicide screening trial. Twelve fungicides were tested in duplicate for their effect on germination of sugarcane seedpieces. Variety C1 41-223, planted on extensive acreage, was selected for this experiment established on high organic matter sand. Both untreated and hot water treated seedpieces (in this paper hot water treatment refers to seedpieces immersed in water at 52 C for 20 minutes) were dipped in fungicides for two minutes. Each plot consisted of a single row 10-ft long containing 8 15-inch seedpieces having a total of 30 undamaged buds. The seedpieces were planted end to end with the upper portion being placed as close to 3 inches from the soil surface as possible. Emergence counts were made each week but the results at 4 weeks after planting are the only ones reported since they represent maximum difference due to treatments.

Tersan 75 trial. Tersan 75 was selected for further testing in a trial with 8 treatments and 6 replications arranged in a randomized block design. Each plot consisted of 8 15-inch seedpieces having a total of 26 undamaged buds. Since dipping seedcane in a toxic material presents handling problems, applying a fungicide as a spray in the field appeared to be desirable. All seedpieces except the controls received the hot water treatment. Treatments consisted of a control, hot water only, hot water plus a Tersan 75 spray at 100, 500, 1,000, 5,000 and 10,000 ppm, and hot water plus a 2-minute dip in 10,000 ppm Tersan 75 (in this paper ppm is active ingredient). Seedpieces were placed in the soil as described in the fungicide screening trial. This experiment was conducted on an Okeelanta peaty muck soil using Cl 54-378, a variety that germinated relatively slowly. Numbers of shoots at 5 weeks after planting are reported.

Stubble cane trials. Two field trials were established on an Everglades peat soil. One trial was planted in a field of 4-to 12-inch-tall Cl 54-378 stubble that yielded 41 tons cane per acre the previous crop, while the second trial was established in a field of 6-to 18-inch-tall Cl 54-378 stubble that yielded 48 tons cane per acre the previous crop. At the time of replanting, the 48 ton field had a considerably better stand than the 41 tons per acre field. In each field an area having an average stand was selected and cane stools were removed for the establishment of the single row 15-ft plots. All plots were located between rows of undisturbed stubble cane.

Treatments consisted of undisturbed stubble, untreated seedpieces, hot water treated seedpieces, and hot water treated seedpieces dipped for 2 minutes in a 12,000 ppm Tersan 75 suspension. Plots were arranged in a randomized block design having 6 replications. Seedpieces 15 inches long having 2 to 3 buds were planted with 1/3 overlap and the upper portion 4 inches below the soil surface. Data on shoot counts and total inches of stalk (measured to the top visible dewlap) were collected during the growing season. The cane from the experimental plots was weighed and analyzed for sucrose just prior to the commercial harvest of the fields involved.

Difolatan trial. In a later trial, Difolatan (cis-N-[(1,1,2,2-tetrachloroethyl)thio]-4-cyclohexene-1,2-dicarboximide), an easy to work with, low toxicity fungicide, was used to treat seedpieces of variety Cl 54-378 planted on an Okeelanta peaty muck. The following treatments were made: No immersion or dip (control), 2 minute Difolatan dip (12,500 ppm), hot water immersion, hot water immersion plus Difolatan spray (12,500 ppm), hot water immersion plus a 2 minute Difolatan dip (12,500 ppm), immersion for 20 minutes in hot water containing 12,500 ppm Difolatan, and immersion for 20 minutes in hot water containing 500 ppm Difolatan. Plots were arranged in a randomized block design having 6 replications. Single rows 10-ft long were planted with 8 seedpieces 15 inches long having a total of 24 undamaged buds per plot. Seedcane was placed in the soil as described in the fungicide screening trial. Data on emergence were collected.

RESULTS

In the fungicide screening trial, seedcane treated with Quicksan, a mercurial compound, had the highest emergence at 4 weeks after planting, followed closely by the Tersan 75, Bravo, Topsin M and hot water treatments (Table 1). Quicksan-treated seedcane averaged 40% more shoots while Tersan 75, Bravo, Topsin M and hot water-treated seedcane averaged 20% more shoots than the control at 4 weeks after planting. Seedpieces receiving a hot water treatment plus a 2 minute dip in 12,000 ppm Tersan 75 suspension averaged 80% more shoots than the control and 50% more than the hot water only treatment. Based on the above information Tersan 75 (Tetramethylthiuramdisulfide) was selected for further study.

It was found in the Tersan 75 trial that treatments consisting of hot water immersion and Tersan 75 spray had a higher shoot count in every case (3 to 31% at 5 weeks after planting) than the hot water only treatment (Table 2). The above mentioned increase in shoots was not significant at the 5% level; however, all treatments were significantly superior in germination when compared to the control. Dipping hot water treated seedpieces in water containing 10,000 ppm Tersan 75 significantly improved emergence over all other treatments.

Hot water treated seedpieces in the stubble field experiments were superior to the control in all yield indices; though, in the higher tonnage field, the increase in cane per acre over the untreated seedpieces was not quite significant at the .05 level (Table 3). Seedpieces treated with hot water plus Tersan 75 dip had the highest emergence count at 5 weeks, greatest total inches of stalk (measured to the top visible dewlap) just prior to closing-in and significantly more cane and sugar per acre when harvested than the untreated seedpieces. In both fields hot water treatment combined with the Tersan 75 dip produced more cane and sugar per acre than the hot water only treatment; however, in the high tonnage field the increase was not significant at the 5% level.

Table 1. Fungicide screening trial treatments and emergence count..

Treatment	ppm ai ^{1/}	Number of shoots ^{2/}
Quicksan	500	28
Tersan 75	12,000	24
Bravo	12,900	24
Topsin M	500	24
Hot water	-	24
Mertect	1,000	23
Che 1843	300	21
Captan	4,200	20
Dithane M-45	28,000	20
RH-893	100	20
Control	-	20
Basic copper	2,500	18
Dëxon	200	17
Benlate	300	5
Tersan + hot water	12,000	36
Mertect + hot water	1,000	34
Dithane 45-M + hot water	28,000	33
Bravo + hot water	12,900	33
Topsin M + hot water	500	32
RH-893 + hot water	100	30
Basic copper + hot water	2,500	29
Captan + hot water	4,200	28
Dëxon + hot water	200	28
Che 1843 + hot water	300	26
Quicksan + hot water	150	26
Hot water	-	24
Benlate + hot water	300	24
Control	-	20

^{1/} Rates in terms of active ingredients were generally based on quantities of fungicides used on crops other than sugarcane.

^{2/} Shoot count taken 28 days after planting (11/10/72); totals for two replications.

Table 2. Tersan 75 trial emergence data.

Treatment	Numbers of shoots ^{1/}	
	Total	Average ^{2/}
Hot water + Tersan 75 dip (10,000 ppm ai)	74	12.3 a
Hot water + Tersan 75 spray (500 ppm ai)	55	9.2 b
Hot water + Tersan 75 spray (10,000 ppm ai)	50	8.3 b
Hot water + Tersan 75 spray (1,000 ppm ai)	49	8.2 b
Hot water + Tersan 75 spray (5,000 ppm ai)	44	7.3 b
Hot water + Tersan 75 spray (100 ppm ai)	43	7.2 b
Hot water	42	7.0 b
Control	1	0.2 c

^{1/} Shoot count taken 5 weeks after planting (1/28/74).

^{2/} Average numbers of shoots per 10 feet of row. Means followed by the same letter are not significantly different from each other at the .05 level using Duncan's new multiple range test.

Table 3. Stubble cane trial emergence and yield data.

Treatment ^{1/}	Number of shoots		Inches of stalks ^{2/} 7/2/73	Tons per acre	
	4/23/73	5/7/73		Cane	96 ⁰ sugar
41 ton field ^{3/}					
Undisturbed stubble cane	--	--	--	39.3 a	4.96 a
Hot water + Tersan 75 dip (12,000 ppm ai)	6.2 a ^{4/}	13.5 a	1,370	27.8 b	3.43 b
Hot water	3.5 b	11.3 a	758	18.2 c	2.20 c
Untreated seed	0.5 c	4.3 b	443	10.0 d	1.19 d
48 ton field ^{5/}					
Undisturbed stubble cane	--	--	--	44.4 a	4.93 a
Hot water + Tersan 75 dip (12,000 ppm ai)	8.0 a	17.3 a	1,244	15.7 b	1.73 b
Hot water	8.8 a	15.7	904	13.5 bc	1.33 b
Untreated seed	1.0 b	5.3 b	433	8.3 c	0.87 c

^{1/} The plots were planted 3/29/73.

^{2/} Average inches of stalks (measured to the top visible dewlap) per 15 feet of row.

^{3/} Previous crop averaged 41 tons cane per acre.

^{4/} Averages 6 replications. Means followed by the same letter in the same column are not significantly different at the .05 level using Duncan's new multiple range test.

^{5/} Previous crop averaged 48 tons cane per acre.

Table 4. Difolatan trial emergence data.

Treatment ^{1/}	Numbers of shoots ^{2/} Weeks after planting	
	5	7
Difolatan hot H ₂ O immersion (500 ppm ai)	8.67 a	10.83 a
Hot H ₂ O + Difolatan dip (12,500 ppm ai)	8.50 a	10.33 a
Hot H ₂ O + Difolatan spray (12,500 ppm ai)	7.17 a	9.50 a
Difolatan hot H ₂ O immersion (12,500 ppm ai)	7.50 a	9.33 a
Hot H ₂ O	4.17 b	5.83 b
Difolatan dip (12,500 ppm ai)	0.33 c	3.83 bc
Control	0.67 c	3.33 c

^{1/} Planted 11/27/74.

^{2/} Average number of shoots per 10 feet of row. Means followed by the same letter in each column are not significantly different from each other at the .05 level using Duncan's new multiple range test.

A comparison of results obtained from the lower and higher tonnage fields shows that both cane and sugar production for all treatments were lower, in relation to the undisturbed stubble, in the high tonnage field. It should be pointed out that the sugarcane in the higher tonnage field was 6 to 18 inches tall at the time of replanting as compared to 4 to 12 inches in the lower tonnage field. The increased competition due to more and taller cane in the higher tonnage field contributed to the lower yields of all replant treatments.

Difolatan-dipped seedcane did not germinate faster than untreated seedpieces (Table 4). Hot water treated seedpieces had significantly more shoots at 5 weeks than the above mentioned treatments. Hot water treated seedpieces either sprayed with or dipped in water containing 12,500 ppm Difolatan had significantly more shoots than the hot water only treatment at both 5 and 7 weeks. Treating seedpieces for 20 minutes in hot water containing 12,500 or 500 ppm Difolatan was as effective in stimulating germination as treating seedpieces with hot water and a separate Difolatan dip.

DISCUSSION AND CONCLUSIONS

Results of a screening trial indicated Tersan 75, a non-mercurial compound, was one of the better fungicides tested for accelerating germination of hot water treated sugarcane seedpieces.

In a replicated trial, hot water only and in combination with Tersan 75 spray and dip significantly increased emergence over the control at 5 weeks. A significant increase in emergence over all other treatments was obtained when hot water treated seedpieces were dipped for 2 minutes in water containing 10,000 ppm Tersan 75.

Immersing seedpieces in hot water at 52 C for 20 minutes accelerated emergence and increased yields over untreated seedpieces in two field trials conducted in stubble fields. When the hot water-treated seedpieces received an additional 2 minute dip in water containing 12,000 ppm Tersan 75, there was an increase in tons cane and sugar per acre over the hot water only treatment.

Increased competition due to more and taller cane at replanting reduced the effectiveness of all treatments. Replanting probably would be more successful in stubble fields producing less than 40 tons cane per acre. An effort should be made to replant before the stubble reaches six inches in height.

Difolatan, a fungicide having a relatively low toxicity, was effective in increasing emergence at 5 and 7 weeks when applied to seedpieces previously treated with hot water at 52 C for 20 minutes. Seedpieces immersed in hot water containing Difolatan at 12,500 or 500 ppm germinated as rapidly as those having separate hot water treatment and fungicide dip. Treating with the fungicide in the hot water will greatly simplify seedpiece treatment in a commercial operation.

Successful replanting can prolong the productive life of the stubble fields from a given planting. Treating seedpieces with hot water and a fungicide should enhance the chances of having a successful replanting operation in Florida.

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SHORT HOT-WATER TREATMENT FOR THE CONTROL OF THE RATOON STUNTING DISEASE^{1/}

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ABSTRACT

The standard hot-water treatment (50 C, 120 min) for the control of the ratoon stunting disease cures most sugarcane stalks, young or old alike. A shorter treatment (52 C, 20-30 min) can cure entire young stalks or younger parts of older stalks. The treated part is considered cured when mature-node symptoms are absent in shoots grown from the treated part or from the progeny of treated parts. The results came from three experiments using the varieties CP 44-101 and Coimbatore. In the first, complete young shoots including tops were treated and planted; in the second, complete shoots with tops were treated, and only the tops were planted; in the third, tops were both treated and planted separately. The tops included the youngest nodes of the stalk and the leaf roll.

INTRODUCTION

Hughes and Steindl's (2) hot-water treatment of 50 C for 2 hours (sometimes with minor modifications) has effectively controlled the ratoon stunting disease (RSD) in sugarcane of diverse ages, origins, and varieties. The success of this treatment has obscured the difference between the heat dosage needed to cure and to control the disease. Control treatments are determined by the maximum amount of heat that could be required. This study was undertaken to determine the heat requirement for the cure of young stalk tissue which is usually not treated or is not treated separately when the disease is to be controlled.

The presence of RSD has usually been diagnosed on the basis of internal symptoms, darkly colored vascular bundles found only in the nodal region of the mature part of the diseased stalk (2). Because of the difficulties associated with reading RSD symptoms (5), the varieties used in the experiments for the present study were selected because they had well-defined symptoms in the greenhouse.

MATERIALS AND METHODS

Within a day of harvest, field-grown shoots of CP 44-101 (*Saccharum* interspecific hybrids) and tops from greenhouse-grown shoots of Coimbatore (*S. spontaneum*) were hot-water treated at 52 C for 10, 20, or 30 minutes in Experiment 1, 30 minutes in Experiment 2, and 25 minutes in Experiment 3, or were left untreated as control. Infected cane was progeny of known RSD-infected cane and disease-free cane was derived from hot-water treated seed cane. As preparation for treatment, the leaf blades near the exposed dewlaps of the shoots and tops were trimmed away and the green sheaths were left to cover the buds. The tops included the leaf roll and the four or five youngest nodes (Nodes 1-4 or 1-5) with leaves with exposed dewlaps.

The entire heat-treated shoots with tops were planted in sand or vermiculite (Experiment 1). When the tops were grown separately from the shoots (Experiment 2 and 3), they were rooted in distilled water and then transplanted to 10- or 15-cm pots. After shoots or tops were planted in the greenhouse, new shoots developed from them and these were grown until they had mature nodes.

When the new main or auxillary stalks were large enough, their mature nodes were examined for nodal symptoms of RSD. One-node cuttings were prepared from some of the stalks of CP 44-101 read for nodal symptoms. From one cutting of each stalk sampled, a new stalk was grown for 6 months before it was removed with alcohol-flamed shears and examined for nodal symptoms. The regrowth from the same pot was allowed to develop again for 6 months, and then the new stalk was examined for nodal symptoms. The stalks that grew from the directly treated cane were designated first-generation stalks, and those that grew from cuttings and their regrowth were designated second-generation stalks.

In the first experiment, RSD-infected, field-grown shoots of CP 44-101 were harvested at soil level on July 1, 1974. The shoots were sorted by size into those (leaf roll and stalk together)

^{1/}Research at this location is done in cooperation with the Louisiana Agricultural Experiment Station.

between 45 and 90 cm long (48 shoots) and those less than 45 cm long (72 shoots). The shoots of each group were assigned at random to hot-water treatments for 10, 20, or 30 minutes, with half the shoots to be treated on the day of harvest and half the following day, or to be left untreated as control. The shoots were planted entire. The first generation of stalks was read for nodal symptoms after 5-1/2 months of growth, and the second generation of stalks was read 6 and 12 months later.

In the second experiment, RSD-infected shoots of CP 44-101 were harvested from the field on August 6, 1974. The 60 shoots were sorted into those with symptoms of mosaic (13 shoots) and those without (47 shoots), and again sorted so that two shoots would be hot-water treated (52 C for 30 min) for each shoot left untreated. After treatment, the tops of the shoots -- the leaf roll and the four youngest nodes with dewlaps exposed -- were removed with alcohol-flamed shears. The tops were rooted, transplanted, and grown for 4-1/2 months before the stalks from them were examined for nodal symptoms; the second-generation stalks were read 6 and 12 months later.

In the third experiment, young auxillary shoots of greenhouse-grown Coimbatore were harvested from five stools infected with RSD, and from four stools without RSD. The tops from each shoot were cut below Node 5 and the oldest bud was removed. The tops from each stool were sorted into those hot-water treated (52 C for 25 min) and those untreated as control. Because of the uneven numbers of tops from the stools, the final sorting resulted in a treated group of 21 infected and 15 RSD-free tops, and an untreated group of 19 infected and 13 RSD-free tops. The stalks which developed from the tops were read for nodal symptoms after 5 months, although a few had been read a month earlier.

RESULTS

In the first experiment, where stalks were grouped by length, the stalks that grew from the shorter seed cane treated for 20 or 30 minutes were predominantly free of symptoms. Stalks from the shorter seed cane which had been treated for 10 minutes or had been left untreated were mostly positive for symptoms as were the stalks from the longer seed cane. The results for those treated on the day of harvest and for those treated the following day are presented in Table 1.

Table 1. Nodal symptoms of RSD in mature stalks from field-grown seed cane hot-water treated at 52 C (CP 44-101).

Treatment	Symptoms in stalks from seed cane ^{1/}							
	45 cm long ^{2/}				45 and 90 cm long ^{3/}			
(min)	+	?	-	+/-	+	?	-	+/-
0	13	0	2	0	12	0	0	0
10	11	0	4	1	12	0	0	0
20	1	2	6	1	12	0	0	0
30	0	1	6	0	8	0	2	2

^{1/}The number of seed cane classified according to symptoms in the progeny. A seed cane was classified as positive (+), doubtful (?), negative (-), or both positive and negative (+/-) according to the symptoms in the stalks growing from it.

^{2/}18 seed canes per treatment.

^{3/}12 seed canes per treatment.

In many of the seed canes, more than one bud germinated. Thus, the 96 seed canes of Table 1 had a total of 173 buds which developed into mature stalks. In most cases, the stalks from the several buds of one seed cane were either all positive or all negative for symptoms of RSD. In a few cases in the hot-water treated group, stalks with symptoms and stalks without symptoms developed from different buds on the same seed cane. Such cases are designated "+/-" in Table 1.

To confirm the diagnosis, 62 of 173 first-generation stalks were sampled and grown for a second generation. The diagnosis of 59 of the 62 second-generation stalks agreed with those of the first generation. The three exceptions were stalks from treated seed cane which had been diagnosed on the basis of first-generation results as +/- . On the basis of second generation results, two of these exceptions were placed in the plus category, and the third was assigned to the minus category in Table 1.

In Experiment 2, RSD-infected shoots with tops were removed after treatment and grown separately; the stalks from these tops were mostly free of RSD symptoms. Stalks from tops from untreated shoots were all diseased (Table 2). The vascular bundles in the mature nodes of stalks from treated tops were unusually well defined but not discolored. A sampling of stalks diagnosed for symptoms as "not positive" from treated seed cane was mostly free of symptoms in the second generation; similarly, a sampling of stalks diagnosed for symptoms as "positive" from untreated seed cane was positive in the second generation (Table 2). The mosaic, which was not cured by this treatment, appeared not to hinder the cure of RSD.

Table 2. The control of ratoon stunting disease by hot-water treatment (52 C for 30 min) in shoot tops of field-grown CP 44-101.

Shoots	Disease	Number of stalks ^{1/} with symptoms of RSD from			
		Tops		Second generation	
		+	not +	+	-
Treated	RSD	0	28 ^{2/}	0	10
Treated	RSD-mosaic	1	8 ^{2/}	1	4
Untreated	RSD	11 ^{2/}	0	2	0
Untreated	RSD-mosaic	4 ^{2/}	0	2	0

^{1/} One stalk per top.

^{2/} Plants grown for a second generation selected from this group.

In Experiment 3, the tops of Coimbatore plants were separated and then treated, and judging by the progeny, most of the tops were cured by the 25-min treatment. In this variety, as in CP 44-101, some symptom-free stalks grew from infected and untreated seed cane; only symptom-free stalks grew from tops of RSD-free shoots, treated or untreated (Table 3).

Table 3. The control of ratoon stunting disease by hot-water treatment (52 C for 25 min) in shoot tops of greenhouse-grown Coimbatore (*S. spontaneum*).

Tops	Number of stalks ^{1/} with RSD symptoms from tops from			
	Diseased stools		Healthy stools	
	+	-	+	-
Treated	1	7	0	8
Untreated	13	3	0	12

^{1/} One stalk per top.

DISCUSSION

A simple interpretation of the result that symptom-free stalks grew from untreated tops or untreated young, whole shoots (Tables 1, 3) is that the concentration of the pathogen could be lower in the younger tissue than in older tissue and that the effective concentration in younger tissue may range down to zero. This interpretation would suggest a possible reason for the lesser heat dosage required to cure RSD in the shorter and presumably younger seed cane (Table 1). If the pathogen were inactivated by heat at a constant rate independent of the host, then initial pathogen concentration would affect the heat dosage needed for inactivation of the pathogen and cure of

the disease. Because host conditions could affect the rate of inactivation, such an explanation is speculative.

The cures obtained indicate that cure of RSD in young tissue requires a heat dosage similar to that required by many diseases which were formerly attributed to viruses and which are now considered to be bacterial in origin (4). The recent observations of bacteria associated with RSD suggest that RSD is a bacterial disease (1,5); the heat requirement for the cure of young tissue is more consistent with this interpretation than the standard control treatment which had placed RSD in a class by itself. It should be noted, however, that chlorotic streak is cured by a hot-water treatment of 52 C for 20 minutes (3) and that there is no evidence for its bacterial etiology.

The finding that young tissue is cured by a relatively short treatment has no practical application. Shoots still highly immature may behave like older tissue (Table 1), and the survival of tops and young shoots exposed to a short hot-water treatment may be no more favorable than the survival of older tissue exposed to the long hot-water treatment.

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DEVELOPMENT OF AN AERATED STEAM SYSTEM FOR THE CONTROL OF
RATOON STUNTING DISEASE IN SUGAR CANE

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ABSTRACT

Studies by plant pathologists have shown that ratoon stunting disease is widespread in canes grown commercially in Louisiana, and that significant increases in yield may be expected when the disease is controlled by heat treatment, such as aerated steam. Aerated steam, a mixture of air and steam, can be adjusted from relatively dry to supersaturated. Development of an aerated steam system involved determining some basic thermal properties of cane stalks, such as specific heat and thermal conductance. The steam system utilizes the efficiency and uniformity of heat transfer through a moist environment, as well as the flexibility of a recirculating air system.

Various components of equipment were assembled to inject the maximum required heat, as steam, into an air stream to increase the cane temperature to a prescribed level. The air-steam circulation and efficient heat transfer within the treatment chamber gives equilibrium temperatures throughout the system. Test results showed the temperatures of the cane-air-steam system were in equilibrium through a 6.0-foot x 6.0-foot clean cane mass within 50 minutes using 10 air transfers per minute in the treatment chamber. The temperature was controlled to -1°F . Similar results were obtained when the stalks were not hand stripped, and there were also indications that young seedpieces have greater tolerance to aerated steam than hot water.

The ability to control diseases in seeds and plants by heat is well documented. A combination of a prescribed treatment temperature and time of exposure is used to inactivate or control ratoon stunting disease in sugarcane. Currently, hot air and hot water are two mediums used for treating sugarcane seed pieces for a specified time and at a prescribed temperature without severely reducing the viability or germination of the seed pieces. The hot water treatment, developed in Australia, consists of immersing seed cane in water at a temperature of 122 F (50 C) for 3 hours. The hot air method, developed and used almost exclusively in Louisiana, utilizes a recirculating air system with the cane seed pieces being exposed to the 129.2 F (54 C) air temperature for a period of 8 hours. Both the hot air and hot water treatment methods require the seed cane to be shucked or cleaned before treatment. A small fluctuation in treatment temperature affects germination and the extent to which the disease is controlled. Hot or cold spots within the treatment chamber affect the germination and disease control. The advantages and disadvantages of both systems contributed to the development of an aerated steam system for treating sugar cane seed pieces. This paper is a progress report on the development of the aerated steam system by the Agricultural Engineering Department and Plant Pathology Department at the Louisiana Agricultural Experiment Station.

Aerated steam is defined as a mixture of air and steam. A constant amount of air conditioned to a predetermined temperature and relative humidity with steam is recirculated until the system reaches thermal equilibrium. Circulation is continued with the addition of steam to insure the prescribed temperature is maintained for a specific length of time. Edison(2) concluded that aerated steam therapy for 1 hour at 122 F (50 C) was superior to hot air or hot water treatments for 8 hours at 129.2 F (54 C) and 2 hours at 122 F (50 C), respectively, in controlling grassy shoot disease. Aerated steam treated canes had high germination and completely inactivated the etiological agent. Baker (1) recommended the use of aerated steam in soil and seed treatment to control diseases in vegetable culture and miseries.

An aerated steam system utilizes the efficiency and uniformity of heat transfer through a moist environment as well as the flexibility of a recirculating air system. The initial phase in the development of an aerated steam system was the design and selection of components to provide the desired environment. A schematic of the pilot system shown in Fig. 1 was composed of 1) a treating chamber, 2) a recirculating air system, 3) a steam generator and 4) a method of controlling the amount of steam applied to the system.

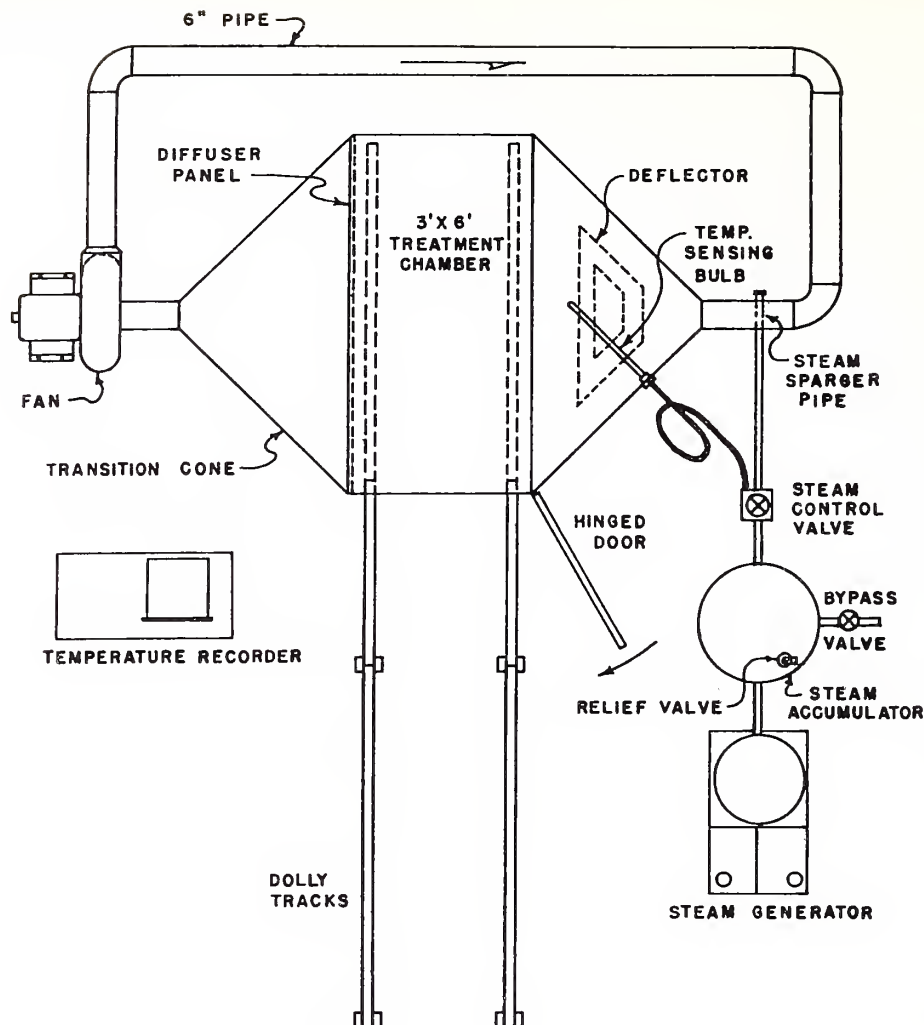


Fig. 1. Aerated steam heat treating system.

The recirculating air entered one side of the treating chamber through a transition. Different sizes of truncated cones were mounted within the transition to break up the air flow and distribute it uniformly across the entrance to the treating chamber. To obtain maximum circulation within the chamber, a perforated deflection plate was mounted over the return air opening. Air circulation was maintained through a 6" (15.24 cm) duct at a velocity of 3,000 ft/minute (15.24 m/seconds) or 590 cfm (.018 m³/minute). Recirculation at a rate of approximately 10 times the empty volume of the treatment chamber was adequate to minimize the blast effect of higher velocities and also to suspend the steam within the turbulent air throughout the chamber.

Components and assembly sequence for the steam injection system are shown in Fig. 2. The steam was generated with an automotive type steam cleaner rated at 100 gallons/hour (.379 m³/hour). Steam from the generator passed through an accumulator where the generator pressure pulses were cushioned. The accumulator also collected condensate and other foreign materials from the system and discharged it through an excess steam bypass valve.

Although the system operates at 30 psi (.206 MN/m²) of steam pressure, the accumulator should be rated at a minimum of 150 psi (1.03 MN/m²) and have a capacity of approximately 20 gallons (7.57 x 10⁻² m³). Steam going to the system was taken from the top of the accumulator and passed through a modulating steam control valve. The amount of steam injected into the recirculating air system to maintain a prescribed temperature was controlled by the steam control valve. A temperature sensing element was placed in the entrance transition to measure the temperature of the aerated steam entering the treating chamber. The sensing element temperature was indicated by a dial thermometer but could be regulated by manually adjusting the spring pressure on the pilot of the steam control valve. Steam passing through the modulating control valve was distributed into the airstream through a steam injection nozzle constructed of 3/4" (1.9 cm) pipe with 1/8" (.318 cm) holes spaced 1" (2.54 cm) apart. The nozzle was positioned horizontally across the diameter of the recirculating air duct with the steam emission holes facing opposite to the direction of air flow. Turbulence within the system thoroughly mixed the air and steam, providing a humid environment at a prescribed temperature for treating the seed pieces.

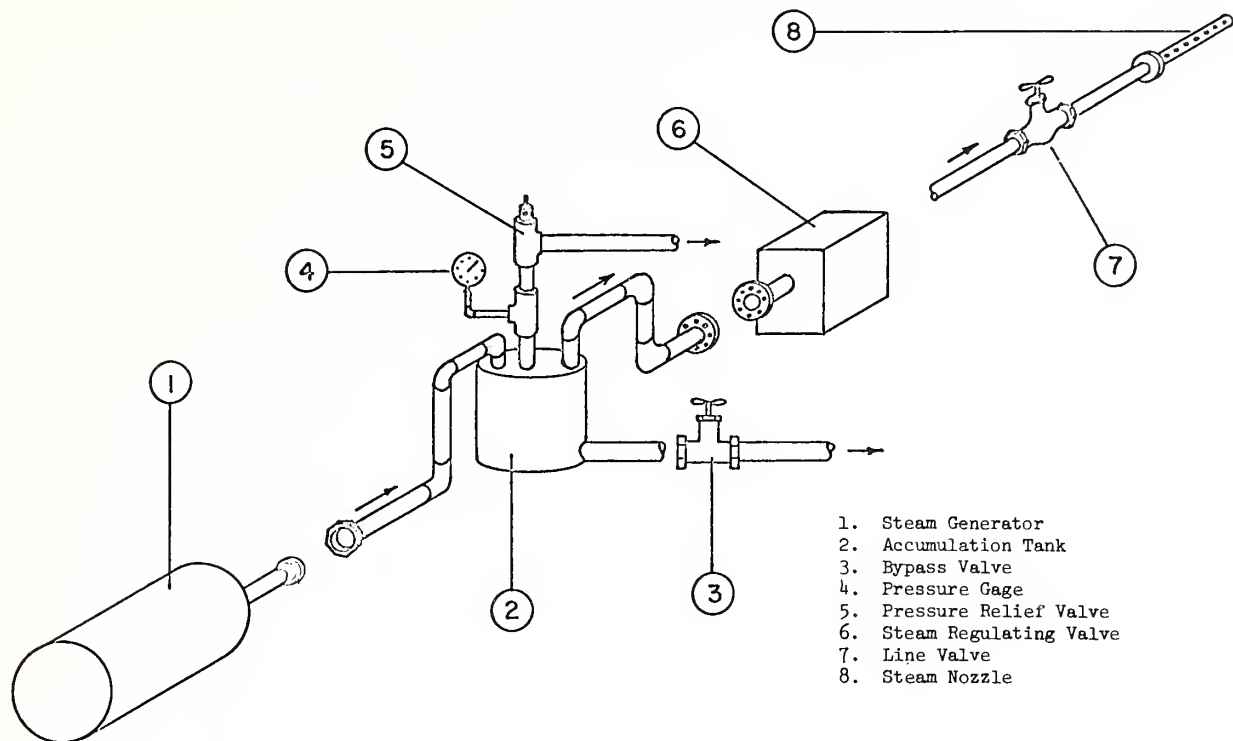


Fig. 2. Components of the aerated steam system.

Copper constantan thermocouples were used in conjunction with a 24 point continuous recording potentiometer to monitor the rate of heat transfer from the aerated steam into the cane stalks as well as to indicate the temperature equilibrium within the treating chamber. The thermocouples were strategically placed in the center of cane stalks, attached to the outside of cane stalks, and at various locations throughout the cane mat within the chamber. Recording the temperature also showed the temperature variation within the system and the relative temperatures of each thermocouple location at a given time.

In general, the cane stalks were stripped of trash and stacked on racks similar to the conventional techniques used for commercial hot air treatment. Results showed temperature equilibrium and distribution within the aerated steam treatment chamber was maintained at ± 1.8 F (1 C). The temperature of all thermocouples was in equilibrium within 1 hr after treatment began. Similar results were obtained when the stalks were not stripped of the leaves or stacked on racks, however, additional research is planned to verify these results.

After the aerated steam was tested using the experimental treatment chamber and the operation parameters established, tests were conducted to determine the feasibility of converting an existing hot air treatment system to the aerated steam system. The following procedure was used to convert the system:

- 1) Remove heating cones or strips and disconnect the electric controls except for the circulation fan.
- 2) Water-proof the inside of the treating chamber and air duct with a sheet metal lining or water-proof spray to prevent damage by steam condensate.
- 3) Drill a 1" (2.54 cm) hole horizontally through the air duct in front of the heating cone area. Insert the steam injection nozzle across the duct with the holes for injecting steam pointed opposite to the air flow.
- 4) Drill a hole through one side of the air duct beyond the heating cone installation and insert the control valve temperature sensing element.
- 5) Connect the steam injection nozzle to the steam generation and control system as previously outlined for the experimental aerated steam unit. The same circulation fan on the hot air chamber was used with the aerated steam system.

A comparison was made between the aerated steam and the hot air treatment to evaluate the rate and uniformity of the internal oven temperatures for both types of treatments. The temperature rose from 60 F (16 C) to 120.2 F (49 C) in 4 hours 20 minutes for the hot air system compared to 1 hour 10 minutes for the aerated steam system. The variation among the points within the treatment chamber

was found to be 1.8 F (1 C) between maximum and minimum temperatures with the aerated steam compared to a difference of 7 F (3.89 C) for the hot air system.

Results of studies with the aerated steam system for heat treating sugarcane to control ratoon stunting disease show considerable promise. Some apparent advantages of an aerated steam system are as follows:

- 1) Relative short time required for the system and cane to obtain temperature equilibrium.
- 2) Provides an environment for efficient heat transfer into sugarcane seed pieces.
- 3) Fast and easy method to vary the rate of temperature change within the treatment chamber.
- 4) Uniform temperature distribution within the treatment chamber.
- 5) Eliminates the accumulation of trash, mud, and extraneous material in the treatment chamber.
- 6) Eliminates stagnant or polluted water in the treatment chamber.
- 7) Has a potential of heat treating cane with leaves attached.
- 8) Adaptable for treating cane handled in bulk.
- 9) No fire hazard.

Essentially all phases of the studies showed positive results. More extensive studies will be continued during 1975 to determine the optimum treatment time and temperature relationship and study arrangements and methods for reducing the labor required for heat treating seed cane in Louisiana.

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THE USE OF AERATED STEAM FOR THE CONTROL OF RATOON STUNTING
DISEASE IN LOUISIANA

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ABSTRACT

Ratoon stunting disease (RSD) of sugarcane, is controlled primarily by heat-treatment of cane with either hot-air or hot water. Hot-air is used in Louisiana. The main disadvantages of the above are a long 8-hour treatment period with hot-air and a reduction in germination with hot water under Louisiana conditions. Tests were conducted in 1974 to determine if aerated steam (AS) could be used for controlling RSD in Louisiana. Stalks were treated in a chamber with the temperature controlled by injection of steam in a recirculating air steam. Treatments studied include chamber temperatures of 49 C, 50 C, and 52 C with disease-free and RSD infected seed stalks being removed at 30 minute intervals over a 4-hour period. Two treated commercial varieties were planted in the greenhouse and field to check germination and disease development. Excellent disease control and good germination were obtained with AS at 49 C for 3 and 4 hours, and 50 C for 2 and 3.5 hours. This new system of treating stalks appears promising. If further studies support these observations, the AS system will be proposed as a new alternative for control of RSD in Louisiana.

INTRODUCTION

Ratoon stunting disease (RSD) of sugarcane is controlled, in Louisiana, with hot dry air (HA) at 54 C for 8 hr (5). Treatment of infected cane with hot water (HW), at 50 C for 3 hr, has been found in Louisiana to reduce the germination of seedcane used for planting (4).

Air heated with steam (aerated steam), found to be effective for controlling seedborne diseases (1), was utilized successfully in India for treatment of sugarcane against grassy shoot (3).

The desirability of finding a better system than HA prompted the authors to test aerated steam (AS) as an alternate method of control.

MATERIALS AND METHODS

During the summer of 1974 the Department of Agricultural Engineering at Louisiana State University constructed an experimental oven for treatment of sugarcane stalks with aerated steam (2). Preliminary tests utilizing AS were conducted between September and November of 1974. A commercial hot air chamber was adapted to heat cane with aerated steam and cane was treated. The cane for the various tests was obtained from the Department of Plant Pathology at Louisiana State University. The treated cane from both chambers was planted under greenhouse and field conditions.

Whole stalks stripped of trash and adhering leaves were treated in the experimental oven. Trash-free and cane with adhering leaves and sheaths were used for the commercial treatment. The stalks were stacked on shelves of a rack similar to the one used for commercial treatments. The temperature/time combinations used for most treatments were as follows: (the treatment duration ranged from 1 hr through 4 hr with removal of stalks at 30 minute intervals for the various treatments used): 49 C (120.2 F), 50 C (122 F) and 52 C (125.6 F). Cane treated with hot air at 54 C (129.2 F) for 8 hr was included in the experiments.

Greenhouse tests. For the greenhouse tests the stalks of the various treatments were cut into one eye pieces and planted in trays. Germination count was made 3 weeks later, and after 10 weeks each shoot was split open and examined for juvenile symptom (a pinkish discoloration of immature nodes of young shoots), a method for identification of RSD in Louisiana.

Field tests. Treated cane was planted in the field in early October to determine the effects of treatment, after overwintering, on germination and RSD control in varieties L 62-96 and CP 65-357. Whole stalks were used for planting the field plots and commercial type cultivation was used. The next spring, in May, a stand count was made and original mother shoots arising were examined for juvenile symptoms. Only variety L 62-96 was examined since it was found from previous work that like variety CP 44-101, it is a reliable indicator of RSD in young cane under field conditions in the spring (5). The field tests were also aimed to determine if the juvenile symptom found in the field was correlated with greenhouse results obtained from the same treatments.

Observation of causal agent. The RSD causative agent recently has been reported to be a bacterium (5). In order to verify that the RSD causative agent was present in young shoots, juice was expressed from nodal tissue of shoots with juvenile symptoms and shoots with no symptoms, and examined under the electron microscope for detection of the suspected agent.

EXPERIMENTAL RESULTS AND DISCUSSION

Greenhouse tests. Stand counts and examination of cane shoots revealed good germination and satisfactory RSD control. Results of the first three tests using L 62-96 and CP 65-357 are given in Table 1. The first treatment at 49 C (120.2 F) showed that this temperature and a maximum time of 4 hr did not adversely affect germination of both varieties; in fact, up to 3.5 hr of exposure resulted in a germination increase; and no juvenile symptom was found after an exposure of 3 hr.

Table 1. Treatment of stalks of sugarcane variety L 62-96 using aerated steam.

Treatment hr	Treatment temperature					
	49 C (120.2 F)		50 C (122.0 F)		52 C (125.6 F)	
	September 17, 1974		November 7, 1974		October 11, 1974	
	% germ.	% RSD	% germ.	% RSD	% germ.	% RSD
1.0	116.0	27.8	100.0	66.7	86.0	43.0
1.5	127.0	14.3	100.0	19.0	86.0	0
2.0	122.0	15.4	92.5	0	73.9	0
2.5	127.0	8.3	100.0	0	60.8	0
3.0	127.0	0	92.5	0	73.9	0
3.5	116.0	0	80.0	0	56.5	0
4.0	88.0	0	97.5	0	13.0	0
Check	100.0	100.0	100.0	100.0	100.0	100.0

Greenhouse test

Method of RSD identification - juvenile symptom

The treatment at 50 C (122 F) did not impair germination after 3.5 hr, and RSD was eliminated after 2.0 hr.

A treatment of 52 C (125.6 F) for 1.5 hr was found to be sufficient to eliminate RSD without severely reducing germination in both varieties; however with 3.5 hr germination was reduced to 56.5% of the check.

Field tests. Table 2 shows that the AS treatment at 49 C for 4 hr, and the HA treatment at 54 C for 8 hr resulted in an increase in germination when a stand count of the field tests was made in May 1975.

Table 2. Field germination of L 62-96 treated for RSD control with hot air (HA) and aerated steam (AS)

Treatment	Time (hr)	Avg. % germination	% RSD control
<u>AS 49 C (120.2 F)</u>			
	4		
RSD (Exp. Oven)		148	96
RSD (Com. Oven)		157	96
DF (Exp. Oven)		99	100
<u>HA 54 C (129.2 F)</u>			
	8		
RSD (Com. Oven)		131	100
DF (Com. Oven)		134	100
<u>Check</u>			
RSD (Com. Oven)		100	0
RSD (Exp. Oven)		100	0
DF (Exp. Oven)		100	100

* - 1 Row 20 feet. Treated Oct. 4, 1974 Examined May 15-20, 1975 Method of RSD identification - Juvenile symptom

The results show that RSD infected L 62-96 cane after treatment at 49 C for 4 hr in the experimental AS chamber, and in the adapted standard HA chamber, was not completely free of RSD: 4.0% of the shoots were found with RSD symptoms.

Unlike field results, if the juvenile symptom was used under greenhouse conditions for RSD identification it was found that an AS treatment of 49 C for only 3 hr completely controlled the disease. Field results would seem to indicate that some of the RSD causative agent was not completely destroyed in some of the shoots although greenhouse results indicated complete control. These results also seem to indicate that if the concentration of the RSD agent is reduced or almost eliminated by the treatment, a certain amount of time is required for it to multiply before it again causes the young shoot to produce the pinkish discoloration. Under Louisiana conditions, the fall growth after planting, winter dormancy, and spring growth through May, a 7 1/2 month period could be sufficient time for expression of the juvenile symptom in nodes of cane not completely freed of RSD by an inadequate heat treatment.

Observation of causal agent. From seven samples, of juice in shoots with juvenile symptom, examined under the electron microscope, a similar bacterium type was detected in six of them; while juice from symptomless shoots was free of the bacterium.

CONCLUSION

A temperature/time combination for AS of 49 C for 4 hr was chosen for the initial tests instead of 50 C for 3 hr because previous results had shown hot water at 50 C for 3 hr would injure immature cane in Louisiana. Results of the tests in 1974-75 have shown that it is possible to treat cane with AS using a temperature/time combination of 49 C for 4 hr which will give acceptable RSD control and not reduce germination. The results also indicate that it may be possible under Louisiana conditions to use 50 C for a period of 3 to 4 hr with good germination and excellent disease control with AS.

Preliminary results in Louisiana with the present commercial hot-air chamber showed that it could be converted to AS at a minimum cost. If the oven is properly loaded, cane with adhering leaves may be treated successfully according to internal oven temperatures obtained during preliminary trials.

Use of an AS treatment has several advantages over hot air and hot water. In comparison with hot air, the period of treatment may be reduced by 4 hr; it is much more economical since heat is generated by use of fuel instead of electricity; the unit is movable since the heat source is portable; only 110 V electricity is needed; internal oven temperature is controlled within 1 C allowing better heat control during the treatment period, and the even distribution of the temperature in the oven may allow treating cane with adhering trash. In comparison to hot water, AS has the big advantage of not requiring a large quantity of steam or electricity and it does not injure young cane as severely as hot water.

More tests with AS will be conducted in 1975 to determine which is the best temperature/time combination to use for control of the ratoon stunting disease of sugarcane under Louisiana conditions.

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SOME CALCULATED COSTS AND RETURNS FROM MONITORING FLORIDA
SUGARCANE FOR THE SUGARCANE BORER, DIATRAEA SACCHARALIS (F.)

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ABSTRACT

The price of raw sugar, and the cost, and effectiveness of control measures are variables which influence the point at which a given infestation of the sugarcane borer reaches an economic threshold. In determining the urgency to apply treatment for control at a given level of infestation, the stage of borer development, and the presence of parasites, predators and diseases of the borer should be considered. A field case study is presented.

PARASITISM AND CONTROL OF THE SUGAR CANE BORER
BY FIELD RELEASED LIXOPHAGA DIATRAEA (T.)

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ABSTRACT

During the past several years, the Tachinid parasite, Lixophaga diatraeae, released in one-third acre to 100-acre field plots, caused various degrees of parasitism of the sugar cane borer. In 1974, 78 percent parasitism was recorded by June 26, when releases were begun June 6. Damaged internodes in the release site at harvest time was 5.7 percent, while damaged internodes in control areas ranged up to 33 percent.

HOST RESISTANCE TO DIATRAEA SACCHARALIS (F.): RELATIONSHIP OF SUGARCANE
INTERNODE HARDNESS TO LARVAL DAMAGE^{1/}

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ABSTRACT

The rind hardness of the lowest internode enclosed by the uppermost leafsheath in which first instar Diatraea saccharalis (F.) larvae were found was determined for 8 commercial sugarcane varieties. A highly significant negative correlation ($r = -.97$) was found between the internode first accessible to attack and mean percent internodes subsequently bored by D. saccharalis larvae. The possibility of using this technique to differentiate host resistance to D. saccharalis in sugarcane breeding programs is promising.

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MODIFICATION OF PINTO BEAN DIET FOR THE SUGARCANE BORER
WITH SUGARCANE PLANT PARTS

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ABSTRACT

The sugarcane borer, Diatraea saccharalis (F.), has been artificially reared on the pinto bean diet for several years. The lighter weight of reared pupae, compared to wild pupae collected in the field, prompted an investigation into diet improvements. Substitution of one-half of the pinto beans in the standard diet with ground, oven-dried sugarcane leaf blades increased the mean weight of female pupae from 125 milligrams to 151 milligrams, and male pupae 88 milligrams to 106 milligrams. The mean length of the larval period was decreased from 24.5 to 18.4 days for females, and from 22.5 to 17.5 days for males. Sugarcane tops, without leaf blades, gave similar results. Freshly expressed juice from mature cane stalks depressed normal growth and development when substituted for any major diet ingredient, including water. Experiments showed that at least part of this decrease in growth may have been due to the sucrose content of the juice.

THE COMPARATIVE EFFICIENCY OF PRE- AND POSTEMERGENCE
HERBICIDES THAT ARE NOT LABELED FOR USE IN
LOUISIANA SUGARCANE

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ABSTRACT

Three new chemical herbicides used in preemergence applications to control weeds and grasses have shown and continue to show promise in Louisiana sugarcane. Some of these are in the process of being registered and labeled with EPA for use in the future. The three that are most outstanding at the present time for preemergence use are Chemagro's sencor, Elanco's spike and DuPont's Velpar. The only new postemergence chemical that has shown promise to date is Rhodia's Asulox. Data on yield performance of sugarcane treated with these chemical herbicides are shown in this paper and discussion on dates of application and rates per acre are also presented.

INTRODUCTION

Only two chemicals are being recommended for use as preemergence herbicides in Louisiana sugarcane that have long residual effect on weeds and grasses. These are Amchem's fenac and DuPont's sinbar. Additional preemergence chemicals are needed by the growers because both fenac and sinbar when used alone have disadvantages that are outstanding.

Fenac has a shorter residue than sinbar and is less effective on some winter growing grasses (especially Canary grass) than does sinbar. Sinbar on the other hand is more phytotoxic to some varieties of sugarcane than fenac and does not control some grasses and weeds that fenac controls.

Johnsongrass growing from rhizomes continues to be a serious pest in stubble crops of sugarcane in Louisiana. Infestation levels vary considerably from one block of sugarcane to another block and sometimes within the block or from one end of the row to the other end. This makes evaluation of chemical herbicides difficult and the only true evaluation is the compared yield results. Percentage control or rated evaluation are of very little significance and was not used in these studies. The yield of sugarcane in tons sugarcane per acre, pounds of sugar per ton, and pounds of sugar per acre reflects control of grass and any phytotoxic effect of the chemical.

The only chemicals that gave acceptable control of johnsongrass rhizomes from 1950 to 1970 were TCA and dalapon along with silvex for broadleaf weed control. In 1970 asulum (asulox) was introduced into trials and showed promise for johnsongrass growing from rhizomes and other broadleaf grasses.

MATERIALS AND METHODS

It has been known for many years that sugarcane varieties respond differently when chemical herbicides are applied either preemergence or postemergence. It is difficult to obtain information on a newly release variety of sugarcane since the grower wants to increase the new variety as rapidly as possible. This condition in research has changed since the sugarcane station has been located at St. Gabriel, La. where seed of the newly released variety can be obtained without interfering with the outfield grower. The variety CP 65-357 was treated with two labeled and registered and two chemicals not registered and labeled in the 1973-74 test. Variety L 62-96 was used in the comparison. The results of this test in the yield of sugarcane in tons per acre, sucrose, pounds of sugar per ton, and pounds of sugar per acre are shown in Tables 1 and 2.

All chemicals gave excellent control of both broadleaf weeds and grasses at the rates used. All treatments were superior to the untreated check but there were no consistent differences in the yield of sugarcane between or among the treatments. No phytotoxicity to the sugarcane was noted in either variety from the rates of chemicals used in this test. The newly released variety CP 65-357 was superior in yield over L 62-96 in all treatments including the untreated checks.

Three plant cane tests were conducted on Alma Plantation in 1973 and continued in 1974. The variety used was CP 48-103 planted September 20, 1973 and the fall applications of chemicals were made September 21, 22 of 1973. Spring repeat applications were made March 12-15, 1974.

Table 1. The comparative effect of different chemicals used as herbicides on plant sugarcane (CP 62-96) applied in fall and spring at St. Gabriel - 1973-74.

Treatment and rate per acre	Tons of clean cane/ acre	Normal juice sucrose	Lb 96° sugar/ton	Lb 96° sugar/acre
Untreated check	18.2	15.30	221.3	4028
Spike 1/2 lb fall - 1/2 lb spring ^{1/}	26.3	15.25	220.5	5799
Sencor 1 lb fall - Sinbar 2/3 lb spring	26.8	14.86	213.9	5733
Sinbar 2/3 lb fall - 2/3 lb spring	25.9	15.21	219.8	5693
Sinbar 2/3 lb fall - Sencor 1 lb spring	25.7	15.00	216.3	5559
Fenac 4 qts fall - Sencor 1 lb spring	25.9	14.77	212.4	5501
Sinbar 2/3 lb fall - Fenac 4 qts spring	24.1	15.45	223.8	5394
Spike 1 lb fall - 1 lb spring	24.8	14.98	216.0	5357
Sencor 1 lb fall - 1 lb spring	21.8	15.50	224.6	4896
Fenac 4 qts fall - 4 qts spring	21.5	14.91	214.8	4618

^{1/}Wettable powders and water soluble materials on commercial basis.
Application rates on a 30-inch band - broadcast rate x 5/12.
Sencor 1 lb of 70% material or 1 1/2 lbs of 50% wettable powder.
Fenac plus 1 lb silvex per acre.

Table 2. The comparative effect of different chemicals used as herbicides on plant sugarcane (CP 65-357) applied in fall and spring at St. Gabriel - 1973-74.

Treatment and rate per acre	Tons of clean cane/ acre	Normal juice sucrose	Lb 96° sugar/ton	Lb 96° sugar/acre
Untreated check	28.6	13.80	195.9	5603
Sinbar 2/3 lb fall - Sencor 1 lb spring ^{1/}	45.3	13.90	197.7	8956
Sencor 1 lb fall - Sinbar 2/3 lb spring	48.0	12.63	175.4	8419
Spike 1 lb fall - 1 lb spring	38.6	13.30	187.2	7226
Spike 1/2 lb fall - 1/2 lb spring	39.0	13.03	182.5	7118
Sinbar 2/3 lb fall - Fenac 4 qts spring	35.8	13.53	191.2	6845
Fenac 4 qts fall - Fenac 4 qts spring	33.2	14.19	202.6	6726
Fenac 4 qts fall - Sinbar 2/3 lb spring	35.8	13.16	184.8	6616
Sinbar 2/3 lb fall - Sinbar 2/3 lb spring	33.2	13.55	191.5	6358
Sencor 1 lb fall - Sencor 1 lb spring	31.9	13.86	196.9	6281

^{1/}Wettable powders and water soluble materials on commercial basis.
Applications rate on a 30-inch band - broadcast rates x 5/12.
Sencor 1 lb of 70% or 1 1/2 lbs of 50% wettable powder.
Fenac plus 1 lb silvex per acre.

Three blocks of sugarcane, consisting of 3 to 4 acres in each block, were used and the entire block was treated. Block 1 of which yield results are shown in Table 3 was treated with four quarts of fenac plus one pound of silvex. Block 2 with yield results shown in Table 4 was treated with 2/3 pound of sinbar. Block 3 with yield results shown in Table 5 was treated with 1 pound of 70% Sencor in the fall.

Table 3. The effect of preemergence chemical herbicides used in the fall and spring on plant sugarcane on the yield in 1974. Alma Plantation - 1973-74 (CP 48-103).

Spring treatment and rate per acre	Millable stalks/acre	Tons clean cane acre	Normal juice sucrose	Lb 96° sugar/ton	Lb 96° sugar/acre
Four quarts Fenac plus 1 lb Silvex per acre - Fall 1973					
Check (Fenac in fall)	27,001	17.3	15.02	216.6	3747
Sinbar 2/3 lb ^{1/}	37,076	35.6	15.67	227.5	8099
Fenac 4 qts + silvex 1 lb	36,673	30.8	15.58	226.0	6961
Spike 1/2 lb	33,046	29.1	14.76	212.2	6175
Sencor 1 lb ^{2/}	31,031	28.5	15.02	216.6	6173
Spike 1 lb	33,852	25.7	14.67	210.7	5415

^{1/}Commercial rate applied on 30-inch band - broadcast rate x 5/12.

^{2/}Sencor 1 lb of 70% or 1 1/2 lbs 50% wettable powder. Fall application Sept. 21 - Spring March 12-13, 1975.

Table 4. The effect of preemergence chemical herbicides used in the fall and spring on plant sugarcane on the yield in 1974. Alma Plantation 1973-74 (CP 48-103).

Spring treatment and rate per acre	Millable stalks/acre	Tons clean cane/acre	Normal juice sucrose	Lb 96 ^o sugar/ton	Lb 96 ^o sugar/acre
<u>2/3 lb Sinbar applied in fall 1973 on 30-inch band</u>					
Check (Sinbar in fall 1973)	25,792	19.6	15.12	218.3	4279
Spike 1 lb ^{1/}	38,927	35.8	15.61	226.5	8109
Sencor 1 lb ^{2/}	29,016	22.1	14.95	215.5	4763
Spike 1/2 lb	30,225	21.8	13.92	198.0	4316
Fenac 4 qts plus silvex 1 lb	28,210	20.3	14.48	207.5	4212
Sinbar 2/3 lb	27,001	19.4	14.15	202.0	3919

^{1/}Commercial rates used and applied on a 30-inch band - broadcast rate x 5/12.

^{2/}Sencor 70% 1 lb or 50% at 1 1/2 lbs on the band.

Fall application Sept. 21 - Spring March 12-13.

The purpose of the three tests was to determine the effect of the repeated application of the same chemical or other chemicals used in the spring on the yield of sugarcane, sugar per ton and sugar per acre.

RESULTS OF PLANT CANE TESTS

There was not a heavy infestation of johnsongrass seedlings in any of the plant cane tests but annual weeds and grasses were prevalent. It may be seen from Tables 3, 4 and 5 that none of the three chemicals carried over from the fall to prevent grass and weed infestations as reflected by the cane yield. There was very little difference in the yield of any of the untreated spring checks that had been treated in the fall. These data again point out the necessity of splitting applications in the fall and reapplying in the spring for best results. Previous data show that the split application is superior to a single application of the same rate in the spring as the total of the two split applications. The total amount applied in the spring may be phytotoxic to the sugarcane.

Table 5. The effect of preemergence chemical herbicides used in the fall and spring on plant sugarcane on the yield in 1974. Alma Plantation 1973-74 (CP 48-103).

Spring treatment and rate per acre	Millable stalks/acre	Tons clean cane/acre	Normal juice sucrose	Lb 96 ^o sugar/ton	Lb 96 ^o sugar/acre
<u>1 lb of 70% or 1 1/2 lb 50% Sencor applied on 30-inch band in fall</u>					
Check (Sencor in fall) ¹	26,598	17.0	15.61	226.5	3851
Spike 1/2 lb ^{1/}	37,494	35.9	15.23	220.1	7902
Sencor 1 lb ^{2/}	37,927	36.4	15.01	216.5	7881
Fenac 4 qts + silvex 1 lb	35,061	29.5	15.18	219.3	6469
Spike 1 lb	35,061	29.5	13.96	198.7	5864
Sinbar 2/3 lb	25,792	20.6	13.90	197.7	4073

^{1/}Commercial rates used and applied on a 30-inch band - broadcast x 5/12.

^{2/}Sencor 70% 1 lb or 50% 1 1/2 lb on the band.

Fall application Sept. 21 - Spring March 12-13.

The yield results shown in Table 4 (treated with sinbar) indicate that some injury occurred to the variety CP 48-103 in this soil type by lowering the yield in all treatments when compared to the other two chemical treatments in the fall. An average of all treatments showed that sinbar was low with an average of 23.2 tons of cane per acre, followed by fenac with 27.8 tons per acre and the high of all treatments was sencor with 28.2 tons per acre.

There was a slight shift in the rank in pounds of sugar per acre with fenac leading with 6095 pounds per acre followed by sencor with 6006 pounds per acre and the sinbar group was well down with 4933 pounds per acre.

STUBBLE SUGARCANE

In 1973 four tests were started on Alma Plantation in stubble sugarcane to study the time by seasons and a rate and date of application of asulox. Previous data indicate that the rate and date of application is the most important part of the effective use of asulox.

The results of the summary work with asulox are shown in Tables 6, 7, and 8, which include the comparative summary of rates of asulox and combinations of asulox and dalapon. These data are selected from the range of rates that from the effective lower rate of asulox through the rate that would not be economically feasible and could possibly injure the yield of sugarcane.

Table 6. Yield of stubble sugarcane in tons per acre when treated with Asulox^{1/} and combinations of other chemicals for johnsongrass control at different rates per acre 1970-1974 - 5 years.

Year	Variety	Check	Plantation practice ^{3/}	2 qt	2 qt and 2 1/2 lb dalapon	3 qt	3 qt and 1 1/2 lb dalapon	4 qt	2 qt and 2 qt	4 qt and 4 qt
1970	CP 55-30	29.6	39.1	37.8				40.6		
1970	CP 55-30	16.0	30.5	30.5				33.2		
1971	L 62-96	23.4	20.8					26.3	25.0	23.8
1972	CP 48-103	7.4	19.8						32.1	33.4
1972	CP 48-103	14.4	22.4	25.5					21.7	
1973	CP 44-101	15.7	20.3		22.9	19.7	24.9	27.2		
1973	CP 44-101 (N.S.) ^{2/}	14.5	20.3		23.0	29.2	27.6			
1973	CP 44-101 (S)	8.3	20.3		19.2	19.8	21.1			
1973	CP 44-101	3.2	17.8		20.6		23.5	24.0	26.4	
1973	CP 44-101	7.9	17.8		29.9	26.1	28.7	25.2	26.4	20.8
1974	CP 48-103	12.6	17.7	19.2	29.0	30.4		36.6	37.2	24.7
1974	CP 48-103	10.3	17.7	24.7		34.0		27.3		
1974	CP 48-103	10.3	17.7	41.8		36.7		25.8		
1974	CP 48-103	12.6	17.7			32.5	32.4	36.6	36.6	
1974	CP 48-103	12.3	17.7	38.1		30.5		35.8		
1974	CP 48-103	12.3	17.7	19.2	29.0	30.4		36.6		

^{1/}Asulox contained 3.34 lb per gallon. All treatments used with 1 pound of silvex per acre for broadleaf weed control.

^{2/}N.S.: not shaved; S: shaved. All other treatments not shaved. Broadcast rates.

^{3/}Plantation practice 2 1/2 lb dalapon repeated after 21 days with 2 1/2 lb. Each treatment with one lb of silvex per acre.

Table 7. Yield of stubble sugarcane in pounds of sugar per ton^{1/} when treated with Asulox and combinations of other chemicals for johnsongrass control at different rates per acre. 1970-1974 - 5 years.

Year	Variety	Check	Plantation practice ^{4/}	2 qt	2 qt and 1 1/2 lb dalapon	3 qt	3 qt and 3 qt	4 qt	2 qt and 2 qt	4 qt and 4 qt
1970	CP 55-30	148.3	139.9	146.9				148.3		
1970	CP 55-30	170.8	133.7	159.9				153.2		
1971	L 62-96	228.7	211.4					223.4	229.5	225.3
1972	CP 48-103	194.0	189.9						175.2	190.7
1972	CP 48-103	185.1	172.9	179.0					180.2	
1973	CP 44-101	185.6	166.8		145.1	171.2	161.3	166.8		
1973	CP 44-101 (N.S.) ^{2/}	146.3	166.8		179.1	167.6	172.3			
1973	CP 44-101 (S)	152.5	166.8		147.1	164.3	152.3			
1973	CP 44-101	155.7	166.8		145.8		159.2	169.8	193.1	
1973	CP 44-101	151.8	166.8	173.5	173.5	179.0	171.7	162.7	193.1	172.6
1974	CP 48-103	225.1	230.6	233.3	231.3	227.5		288.3	235.7	216.1
1974	CP 48-103	217.3	230.6	225.3		228.3		228.3		
1974	CP 48-103	217.3	230.6	219.7		219.1		225.6		
1974	CP 48-103	225.1	230.6			227.5	227.2	227.3	228.3	
1974	CP 48-103	226.3	237.3		220.9		235.7			
1974	CP 48-103	226.3	230.6	233.3	231.3	227.5		227.3		

^{1/}Based on normal juice sucrose. ^{2/}Asulox contained 3.34 pounds per gallon. All treatments used with one pound of silvex per acre for broadleaf weed control. ^{3/}N. S.: not shaved; S: shaved. Broadcast rates. ^{4/}Plantation practice 2 1/2 lb dalapon repeated after 21 days with 2 1/2 lb. Each treatment with one pound of silvex per acre.

Table 8. Yield of stubble sugarcane in pounds of sugar per acre when treated with Asulox^{1/} and combinations of other chemicals for johnsongrass control at different rates per acre. 1970-1974 - 5 years.

Year	Variety	Check	Plantation practice ^{3/}	2 qt	2 qt and 1 1/2 lb dalapon	3 qt	3 qt and 1 1/2 lb dalapon	4 qt	2 qt and 2 qt	4 qt and 4 qt
1970	CP 55-30	4389	5470	5553				6020		
1970	CP 55-30	2113	4078	4877				5086		
1971	L 62-96	5353	4400					5875	5743	5457
1972	CP 48-103	1436	3760						5624	6369
1972	CP 48-103	2665	3873	4565				6026	3910	
1973	CP 44-101	2917	3386		3328	3373	4016	4537		
1973	CP 44-101 (N.S.) ^{2/}	2121	3386		4133	4894	4755			
1973	CP 44-101 (S)	1266	3386		2824	3253	3214			
1973	CP 44-101	498	2969		3003		3741	4075	5098	
1973	CP 44-101	1199	2969	5188	5188	4677	4543	4100	5098	3590
1974	CP 48-103	2836	4082	4479	6708	6916		8356	8768	5338
1974	CP 48-103	2236	4082	5565		7762		6233		
1974	CP 48-103	2238	4082	9183		8041		5820		
1974	CP 48-103	2836	4082			7394	7361	8191	8356	
1974	CP 48-103	2783	4082	9041		6737		8420		
1974	CP 48-103	2783	4082	4479	6708	6916		8356		

^{1/}Asulox contained 3.34 pounds per gallon. All treatments used with one pound of silvex per acre for broadleaf weed control.

^{2/}N.S.: not shaved. S.: shaved. All other treatments not shaved. Broadcast rates.

^{3/}Plantation practice 2 1/2 lb dalapon repeated after 21 days with 2 1/2 pounds. Each treatment with one pound of silvex per acre.

Previous data, not included in this paper, show that early applications of TCA plus dalapon or dalapon alone help to increase stands of stubble sugarcane by suppressing and killing early emerging johnsongrass. An application of asulox at 2 quarts plus 1½ lb of dalapon or 3 quarts of asulox applied to heavily infested areas has given the best overall results. A lower rate of 2 quarts per acre is ample in light infestations under the same conditions.

Asulox has not caused adverse effects on sucrose as shown in Table 6. The total pounds of sugar per acre was increased at all rates per acre and by combinations of asulox and dalapon over the untreated check and the plantation practice.

PRE- AND POSTEMERGENCE HERBICIDES COMPARED IN FLORIDA SUGARCANE^{1/}

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Belle Glade, Florida

ABSTRACT

Eight herbicide treatments were compared over a three-year period in ratoon C1 41-223 sugarcane on peaty muck soil. Each year, the same three preemergence and five postemergence treatments were repeated on the same plots. On several occasions, one or two of the eight replicates were omitted from some analysis, due to locally severe water rat damage, which precluded acceptable data or observations. Significant differences among the eight treatments were rare and confined largely to weed-control performance or to sugarcane tolerance to the herbicides. Observed values for ¹⁴C brix, pol reading, % sucrose, % purity, % juice extraction, and lb 96° sugar/T cane did not differ significantly.

In the third year of the experiment, the significant yield differences noted among the treatments were attributable to the failure of all the chemicals except asulam to control maturing broadleaf panicum. Weed-control performance of the treatments ranged from acceptable to excellent, but asulam performance in control of broadleaf panicum was superior. Asulam will be added to the list of herbicides recommended for sugarcane in Florida when a label is registered by EPA.

INTRODUCTION

Several preemergence herbicides and herbicide combinations have been recommended for use in Florida sugarcane since 1961 (1). This method of weed control has not become popular despite its effectiveness; probably less than 2% of the total acreage is so-treated annually. The major impediments in adopting preemergence herbicides include: necessity of high herbicide rates on organic soil and the concomitant treatment expense; requirement for adequate soil moisture or rainfall for best herbicide performance; interference with subsequent skip replanting. Post-emergence programs have been the major method of chemical weed control in Florida sugarcane. The earliest treatment schedules included 2,4-D for broadleaf weeds and dalapon for grasses. A combination of atrazine, 2,4-D, and surfactant was first recommended in 1963 and this combination, or variations of it, have been the mainstay of local operations since that time (2). Postemergence programs offer the sugarcane grower greater flexibility than do preemergence herbicides. Treatments for specific weed problems can be adopted as needed. The individual per treatment cost is much lower than for preemergence herbicides but the success of postemergence applications depends on proper timing in relation to weed growth.

Until the early 1960's, the most widespread and difficult to control weeds in Florida sugarcane were annual grasses, Alexandergrass, *Brachiaria plantaginea*, crabgrass, *Digitaria* spp., and goosegrass, *Eleusine indica*. Broadleaf weeds were controlled readily with 2,4-D and/or 2,4,5-T. Only pellitoryweed, *Parietaria floridana*, a winter-spring annual required low rates of substituted triazine or urea herbicides for control (3).

Broadleaf panicum, *Panicum adspersum*, has become common and troublesome since the mid-1960's (4). This annual grass is difficult to distinguish from Alexandergrass especially in seedling and juvenile stages. It differs from Alexandergrass in its resistance to ametryne. Broadleaf panicum is the most serious weed in sugarcane on organic soils at present. Several other *Panicum* species, fall panicum, *Panicum dichotomiflorum*, guineagrass, *Panicum maximum*, and witchgrass, *Panicum capillare*, are increasing in spread and intensity from previously limited infestations, and with coast cockspur, *Echinochloa walteri*, and giant bristlegrass, *Setaria magna*, represent potentially serious annual infestants. Only Napiergrass, *Pennisetum purpureum*, is a serious perennial infestant of some cane fields as well as non-crop areas. Two sorghums, sudangrass, *Sorghum sudanense*, and an apparent sudangrass-johnsongrass, *Sorghum sudanense-Sorghum halepense*, hybrid may be locally important.

Florida sugarcane production requires a postemergence herbicide program which will control annual grass without affecting sugarcane. Grower preference is for chemical treatments which facilitate aerial application, spraying broadcast overall to cane and grasses. Such treatments imply a very high degree of selectivity - high phytotoxicity to grass weeds and high safety to sugarcane. The AREC - Belle Glade sugarcane herbicide program has been oriented toward the selection of chemicals methods suited to these requirements, albeit difficult.

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The experiment reported herein was installed to compare the performance of asulam, a promising grass herbicide, with preemergence and postemergence programs which have been effective experimentally and/or commercially over a period of years. The same herbicidal treatments were applied to the same plots in each of three ratoon crops to simulate commercial usage.

MATERIALS AND METHODS

Sugarcane variety Cl 41-223 was planted on Okeelanta peaty muck soil on 21 October 1970 following a summer flooding program. Recommended fertilization and soil insecticide applications were made on opening and covering the furrows, respectively. The entire plot area received a uniform preemergence application of CDAA at 6 lb/A (6.7 kg/ha) plus atrazine at 4 lb/A (4.5 kg/ha) after the planting furrows were closed and the seedbed levelled. During the plant crop the plot area was maintained essentially weed-free with postemergence herbicides as needed. The area was planted to provide 0.02A (0.008 ha) plots four rows wide, 43.5 ft (13 m) long, and 5 ft (1.5 m) apart. Treatments were replicated eight times.

All comparison treatments were applied with small, experimental tractor plot sprayers utilizing commercial Hypro nylon-roller pumps and Spraying Systems flat-fan or flooding-tip nozzles. Water carrier was used for all treatments at a total volume of 30 gpa (280 l/ha). Preemergence and early postemergence treatments were made with an Allis Chalmers "G" wheel tractor. Postemergence directed applications were made with an Oliver OC-3 high-clearance crawler tractor and nozzles mounted on drags or skids. In all cases, the preemergence and early post-emergence sprays were applied broadcast overall to cane and weeds while the second postemergence application was made semi-directed so as to maximize wetting weed foliage and minimize spray contact with cane leaves.

Broadleaf panicum was the major annual grass infestant of the experimental area. Broadleaf weed populations were represented primarily by spiny amaranth, Amaranthus spinosus; groundcherry, Physalis heterophylla; common purslane, Portulaca oleracea; and, black nightshade, Solanum nigrum. Major seasonal infestants included pellitoryweed, Parietaria floridana; crossleaf gromwell, Senecio glabellus; and sowthistles, Sonchus spp.

The following chemicals were used as preemergence herbicides at the pounds per acre active ingredient (lb/A ai) rates reported in the data tables. Alachlor, 2-chloro-2', 6'-diethyl-N-(methoxymethyl) acetanilide as Monsanto's "Lasso"; Atrazine, 2-chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine as Geigy's and CIBA-Geigy's "Atrazine 80W" or AATrex 80W"; and CDAA, N,N-diallyl-2-chloro acetamide as Monsanto's "Radox".

Compounds applied postemergence at the lb/A ai rates given in the tables are listed below. Atrazine as noted above; asulam, methyl sulfanilylcarbamate as Rhodia-Chipman's "Asulox 3.34"; Dalapon, 2,2-dichloropropionic acid, sodium salt as Dow's "Dowpon"; Fenac (2,3,6-trichlorophenyl) acetic acid with 2,4-D acid as Amchem's "Fenac-Plus"; 2,4-D, (2,4-dichlorophenoxy)acetic acid, alkanolamine salts, as Dow's "Formula 40"; and Surf, octylphenoxy polyethoxy ethanol as Rohm & Haas' "Triton X-114" surfactant.

Herbicide application dates for the first, second and third ratoons, respectively, were: preemergence treatments - 29 March 1972; 2 March 1973; and 11 March 1974; and, postemergence treatments - 10 April, 25 May, and 16 June 1972; 16 May and 22 June 1973; and 1 April and 22 May 1974.

The durations of the first, second, and third ratoon crops reported here were 46, 52, and 54, months, respectively.

Visual evaluations of sugarcane tolerance, annual grass weed control, and broadleaf weed control were made periodically. The rating scale values of 1 to 100 in stepwise increments of 5 reflected the poorest to the best of each comparison as referenced to the best plot within each replication. Sugarcane stand counts and stalk measurements (ground to top visible dewlap - TVD) were made occasionally.

The entire plot area was burned prior to cutting in each year. In the first and second ratoons, random 10-stalk samples for juice analysis were taken from burned cane in the pile row after cutting each plot. In the third ratoon the stalk samples for juice analysis were taken from standing cane prior to burning. The samples were evaluated at AREC-Belle Glade using a motor-driven, 3-roller mill, brix hydrometer, and polariscope. The sugar values reported are based on brix and apparent sucrose, were determined from Schmitz's Table (7) and USDA varietal correction factors (6), and were derived with computational programs on a Hewlett-Packard 9100B programmable calculator or a Wang 2200 mini-computer. Plot weights were obtained with a Thompson sugarcane piler-loader with a Martin-Decker sensor loadcell fitted between boom and cane grab. Harvest dates for the plant crop and the first, second, and third ratoons, respectively, were: 2 March 1972, 19 January 1973, 17 January 1974, and 30 January 1975.

Statistical comparisons were based on programs developed for the analysis of variance with the two computational machines indicated above.

RESULTS

The Florida water rat, *Neofiber alleni*, caused severe sugarcane stand damage in replications bordering a main canal and the data presented herein are based on six of the eight replications installed.

Sugarcane growth ratings: Differences among treatments generally were non-significant or small, especially during growth-stress periods or late in the crop (Table 1). Typically, significant differences were noted in June but not in September of 1972. There was an overall tendency for superiority of preemergence treatments in July, 1973. April, 1974, rating values were high, but declined markedly in May in association with ambient and soil moisture stress and severe infestations of broadleaf panicum. Growth recovery noted in June occurred with climatic improvement.

Table 1. Sugarcane growth ratings on dates indicated.

Treatment (lb/A ai)	Jun 72	Sep 72	Jul 73	Apr 74	May 74	Jun 74
Preemergence:	%	%	%	%	%	%
Atrazine (4) + CDAA (6)	99.0	94.5	86.9	98.1	55.6	66.4
Alachlor (8)	94.4	97.3	76.9	98.5	61.9	77.9
Alachlor (4) + Atrazine (4)	95.7	96.5	84.4	100.0	49.4	69.3
Postemergence:						
Dalapon (4) + 2,4-D (1.5)	91.7	94.3	73.1	97.5	61.2	69.3
Atrazine (0.8) + 2,4-D (0.5) + Surf (0.5%)	98.0	96.5	73.1	98.7	60.0	70.0
Fenac (1.5) + 2,4-D (1)	100.0	98.7	73.1	96.2	65.0	77.9
Asulam (2)	98.4	94.7	76.9	98.7	63.7	80.7
Asulam (4)	96.4	95.2	78.1	100.0	67.5	89.3
Asulam (2) + 2,4-D (1)	95.4	91.8	73.7	99.4	69.4	74.3
LSD (5%)	1.6	NSD	3.2	NSD	NSD	NSD
CV %	4.6	5.3	11.6	4.0	33.7	27.9

Sugarcane shoot counts: Shoot counts did not differ significantly among the treatments. Values for shoots per plot in March, 1973 ranged from 256 to 340; July 1973 counts ranged from 186 to 231. This decrease represents an attrition that occurs generally as the growth season advances.

Sugarcane shoot length: Small, but significant, differences in shoot length, ground to top visible dewlap, were recorded in November, 1972, and July, 1973. Such reductions in shoot length were associated with materials that are phytotoxic when applied to sugarcane foliage, e.g., dalapon.

Annual grass weed control: The very high broadleaf panicum population stress in the experimental area reduced rating values below customary levels. Low soil moisture and paucity of rainfall early in the ratoons lowered preemergence herbicide performance. The treatments did not differ significantly in annual grass performance in 1972. Differences were significant in 1973; postemergence programs with dalapon or with asulam were superior. The values reported for April, May, and June, 1974, illustrate an initial near parity of pre- and postemergence treatments; a decline in preemergence performance with time; a gradual improvement of control with dalapon; a marked improvement in grass control with asulam; and a severe failure of atrazine + 2,4-D + surfactant - the Industry stand-by (Table 2).

Broadleaf weed control: The preemergence herbicides generally provided superior broadleaf weed control. Asulam is relatively ineffective as a broadleaf herbicide and plots treated with this compound required a supplemental 2,4-D + silvex application to prevent dominance of the plots by nightshade and groundcherry (Table 2).

Juice quality - $^{\circ}$ brix, pol. reading, % sucrose: These values did not differ significantly among the herbicide treatments in any of the ratoon crops and are not included in the data tables.

Pounds 96 $^{\circ}$ sugar/ton cane: Significant differences were noted for the first and third ratoons for calculated pounds 96 $^{\circ}$ sugar/ton cane. Asulam treatments tended to be at the higher end of the range of values (Table 3).

Table 2. Annual grass and broadleaf weed control ratings on dates indicated.

Treatment (lb/A ai)	Annual grass control					Broadleaf control
	Jun 72	Jul 73	Apr 74	May 74	Jun 74	May 74
Preemergence:	%	%	%	%	%	%
Atrazine (4) + CDAA (6)	65.9	71.4	85.4	66.2	47.1	98.7
Alachlor (8)	69.1	63.6	73.7	61.2	51.4	83.1
Alachlor (4) + Atrazine (4)	68.1	77.9	92.9	75.6	49.3	99.4
Postemergence:						
Dalapon (4) + 2,4-D (1.5)	57.1	90.0	72.5	76.9	77.9	54.4
Atrazine (0.8) + 2,4-D (0.5) + Surf (0.5%)	67.5	67.1	56.2	25.5	20.0	71.9
Fenac (1.5) + 2,4-D (1)	71.6	62.9	68.7	60.6	51.4	45.6
Asulam (2)	49.2	88.6	76.9	87.9	85.0	51.2
Asulam (4)	62.2	96.9	81.2	97.5	98.6	47.5
Asulam (2) + 2,4-D (1)	55.6	76.4	82.5	92.2	92.9	49.4
LSD (5%)	NSD	7.2	4.9	7.0	8.0	8.6
CV %	25.6	24.6	18.1	27.9	33.1	36.6

Table 3. Pounds 96⁰ sugar/ton cane and pounds cane/plot for crop indicated.

Treatment (lb/A ai)	Lb 96 ⁰ sugar/ton cane			Lb cane/plot		
	Ratoon 1	Ratoon 2	Ratoon 3	Ratoon 1	Ratoon 2	Ratoon 3
Preemergence:						
Atrazine (4) + CDAA (6)	243.9	219.4	228.4	1427	951	1052
Alachlor (8)	255.2	230.0	236.3	1334	908	1161
Alachlor (4) + Atrazine (4)	256.9	228.7	224.9	1418	962	1083
Postemergence:						
Dalapon (4) + 2,4-D (1.5)	240.7	219.3	235.8	1267	859	1163
Atrazine (0.8) + 2,4-D (0.5) + Surf (0.5%)	245.1	210.6	223.2	1438	853	952
Fenac (1.5) + 2,4-D (1)	247.4	217.1	234.9	1426	819	1128
Asulam (2)	242.6	217.7	235.1	1373	927	1432
Asulam (4)	255.0	231.0	237.0	1434	948	1422
Asulam (2) + 2,4-D (1)	252.2	227.2	245.6	1461	953	1529
LSD (5%)	4.2	NSD	4.6	NSD	NSD	65
CV %	4.2	6.1	4.8	8.7	14.4	13.0

N.B. Treatment plot weights did not differ significantly in the plant cane crop; average weights ranged from 1197 to 1396 pounds cane/plot.

Pounds cane per plot: Pounds cane per plot did not differ significantly among treatments in the first and second ratoons, but there were significant differences in the third ratoon (Table 3). Asulam treatments were at the higher yield levels for all three ratoons and demonstrated marked superiority in the third ratoon when annual grass competition was extreme. The average experiment yield in the first ratoon, 34.9 tons cane per acre (TCA), dropped to 22.9 TCA in the second ratoon associated with severe moisture stress early in the ratoon followed by excessive moisture and reduced solar insolation in early to mid summer. The average experiment yield increased to 30.3 TCA in the third ratoon; much of the increase was attributable to asulam treatments.

Tons 96⁰ sugar acre: These values tended to parallel those of pounds cane per plot except that significant differences among herbicide treatments occurred in both second and third ratoons. Again, higher values were associated with asulam treatments, particularly in the third ratoon (Table 4).

Pounds sugar/acre/week: These values are based on the foregoing tons 96⁰ sugar/acre. Treatments did not differ significantly in the first ratoon. Differences in the second and third ratoon were significant; those of the third ratoon reflect the obvious superiority of asulam treatments (Table 4).

Table 4. Tons 96° sugar/A and lb sugar/A/week for crop indicated.

Treatment (lb/A ai)	Tons 96° sugar/acre			Lb sugar/acre/week		
	Ratoon 1	Ratoon 2	Ratoon 3	Ratoon 1	Ratoon 2	Ratoon 3
Preemergence:						
Atrazine (4) + CDAA (6)	4.10	2.36	2.99	178.2	90.7	110.7
Alachlor (8)	4.48	2.81	3.44	188.5	108.2	127.4
Alachlor (4) + Atrazine (4)	4.52	2.74	3.04	196.6	104.5	112.6
Postemergence:						
Dalapon (4) + 2,4-D (1.5)	3.64	2.25	3.43	158.7	86.6	127.3
Atrazine (0.8) + 2,4-D (0.5) + Surf (0.5%)	4.31	2.04	2.67	187.4	78.4	98.7
Fenac (1.5) + 2,4-D (1)	4.13	2.10	3.31	183.7	80.7	122.7
Asulam (2)	4.07	2.44	4.23	176.9	101.9	156.8
Asulam (4)	4.50	2.83	4.21	195.8	108.9	155.8
Asulam (2) + 2,4-D (1)	4.30	2.62	4.70	186.7	100.7	174.0
LSD (5)	NSD	0.20	0.21	NSD	7.9	7.7
CV %	12.5	20.0	14.4	12.6	20.3	14.4

SUMMARY

During two of three ratoons, the sugarcane in the experiment reported herein was under strong environmental stress: low ambient humidity and low soil moisture or rainfall early in the season were followed by excessive rainfall and wet soils accompanied by reduced solar insolation when the crop should have commenced maximum growth rate. These conditions also influenced grass weed growth and minimized chemical weed control success.

Generally, herbicide program effects on sugarcane growth were few and were related to chemicals phytotoxic to cane when applied to the foliage, e.g., dalapon. Broadleaf panicum was abundant throughout the experimental area. This annual grass offered strong competition to cane, especially under the inclement weather regime. Grass herbicide programs ordinarily useful and successful did not achieve satisfactory performance, thus emphasizing the value of asulam in controlling broadleaf panicum, especially at advanced growth stages. Heavy infestations of black nightshade and groundcherry in the experimental area were responsible for diminished performance of all postemergence herbicides. Asulam-plots required supplemental herbicide application to control these broadleaf weeds.

Values for brix, pol. reading, and % sucrose in juice did not differ significantly at any harvest date. Pounds 96° sugar/T cane values did differ significantly in two of three ratoons; asulam treatments were at the higher levels.

Significant cane tonnage differences were recorded in the third ratoon only. Asulam treatments were superior, apparently reflecting treatment effectiveness against broadleaf panicum. Tons 96° sugar/A and pounds sugar/A/week paralleled cane tonnage except that significant differences existed in the second and third ratoons, again marked by superior performance of asulam.

Asulam performance under the adverse conditions of this trial demonstrate its value as a potential component of a Florida sugarcane herbicide program for grass control. Asulam will be included in general use recommendations (5) when EPA grants registration and labelling.

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GENETIC UNIFORMITY AMONG AND WITHIN VARIETIES: A POTENTIAL SOURCE
OF VULNERABILITY TO DISEASES AND INSECTS

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ABSTRACT

Genetic uniformity among and within the principal varieties of a cultivated species under agricultural production at any given time has played a major, but frequently unrecognized, role in the occurrence of epidemics of diseases and insects through that uniformity's effect on their vulnerability. Numerous examples could be cited of the harmful influence of genetic uniformity on the vulnerability of varieties, but the recent dramatic role which a lack of genetic diversity played in the 1970 epidemic of southern corn leaf blight that occurred, not only in the southeastern states, but also in the corn belt, has served to focus attention upon this threat to agriculture.

The severity of corn leaf blight in the south and its spread into the corn belt in 1970 was found to be due to the widespread production of corn hybrids possessing identical cytoplasm, i.e., the so-called T male sterile cytoplasm, combined with the genesis of a new race of the leaf blight pathogen which is specifically and highly pathogenic for all hybrids possessing the T cytoplasm.

Studies stimulated by this epidemic, which involved a disease that had never before been a major threat to corn production, were made by a special committee appointed by the National Academy of Sciences. The committee reached the following conclusions: "The key lesson of 1970 is that genetic uniformity is the basis of vulnerability to epidemics. The major question the Committee on Genetic Vulnerability of Major Crops asked was, 'How uniform, genetically, are other crops upon which the nation depends, and how vulnerable, therefore, are they to epidemics?' The answer is that most major crops are impressively uniform genetically and impressively vulnerable." Although sugar cane was not one of the major crops included in the study, its genetic uniformity is readily apparent.

At any given time, only four or five varieties are grown on the bulk of the acreage in Louisiana and Florida, and each variety is a clone with virtually complete genetic uniformity. The mosaic epidemics of the 1920's and the present can be cited as examples that were caused, in large part, by a lack of genetic diversity among the few principal varieties being grown. The current tendency to release and grow only a few genetically related varieties creates a hazardous situation which could lead to epidemics from new diseases or new strains of old pathogens.

Practical solutions to the problem will be extremely complex. The development and release of several varieties of genetically diverse origin is a major undertaking, but this will not necessarily provide a solution, since farmers will tend to grow the few which they prefer. A satisfactory solution may have to include the release of "varieties" which constitute mixtures of several clones having appreciable genetic diversity, despite the obvious problems that this practice would introduce.

INTRODUCTION

For approximately the past 75 years a number of factors have led to a marked and continuous increase in the degree of genetic uniformity both among and within the commercial varieties of our major cultivated crops. One of the most influential of these factors is the adoption of such rigid requirements for the release of new varieties, among American plant breeders, that only a very few new varieties are released during any 5-10 year period. As a consequence, only a few superior varieties are available to growers. An equally important influence is the tendency for growers to concentrate on the production of one or two of the few varieties that are available.

The effect of these and other factors has been the production of a single genetically-pure variety or a few genetically similar varieties on several thousand to several million acres.

Because plant breeders depend upon new varieties as a primary source of parents in their crossing programs, they have been aware for several years of the growing uniformity among these varieties. It has been a major contributing factor in the apparent improvement plateau that was reached during the past 10-15 years in the breeding of many major crop plants.

However, during the period since 1970 plant breeders and other plant scientists have become increasingly aware of another, more serious detrimental effect and potential threat from the

unnatural degree of genetic uniformity that has been created among and within our principal varieties of cultivated plant species: This genetic uniformity causes our cultivated crops to be more vulnerable to attack by disease agents and insect pests.

Although the influence of genetic uniformity on vulnerability to diseases and insects is not a new phenomenon and has not been limited to one or a few crop plants, an event which occurred in 1970 caused the currently - growing awareness of the serious nature of this problem, the urgent need for investigation, and, at least, an initiation of efforts toward a solution. In 1970 a hitherto minor disease of corn, called southern leaf blight, that had been restricted to the southeastern part of the U.S. underwent a sudden alarming increase in severity in the South and, perhaps more disturbingly, also spread into the corn belt. In some fields the disease caused losses of 50% or higher in yield of grain. The estimated loss for the entire U.S. corn crop in 1970 from the disease was 15%. The effect of the disease is shown dramatically by the comparative per acre yields in 1970 and in recent non-disease years. The average yield of corn per acre for the U.S. during the 4 years of 1969, 1971, 1972, and 1973 was 90 bu. These were years in which southern corn leaf blight did not cause appreciable loss. However, in the epidemic year of 1970 the average yield was only 72 bu. per acre.

Investigations conducted by plant pathologists during the epidemic of 1970 revealed that the unusual behavior of southern corn leaf blight in that year was caused by the spread of an apparently new race of the causative fungus, *Helminthosporium maydis*. These studies also brought to light an unusual and totally unexpected feature of the new race of *H. maydis* which accounted for its spread and severity. By 1970 corn hybrids were being grown extensively in the South and corn belt which, though genically diverse, possessed the same cytoplasm--the so-called Texas or T. cytoplasm that causes cytoplasmic male sterility, which was valuable because it eliminated the necessity for expensive hand detasseling of the female parent single cross in the production of double cross hybrid seed. Studies showed that, amazingly, the new race of *H. maydis* was specifically pathogenic on corn hybrids and inbred lines that contained the T male sterile cytoplasm. To dramatize the relationship, the new race was designated race T.

It soon became apparent from the studies that the epidemic of corn leaf blight in 1970 was due basically to the genetic uniformity of many widely-grown corn hybrids in respect to their cytoplasm and that hybrids possessing T male sterile cytoplasm could no longer be planted with safety.

As soon as the facts were available concerning the development of the corn leaf blight epidemic of 1970, the Agricultural Board of the National Academy of Sciences appointed a Committee on Genetic Vulnerability of Major Crops composed of 16 agricultural scientists to examine the subject in detail. The Committee acted quickly and published a lengthy report of its findings in 1972 under the title "Genetic Vulnerability of Major Crops." The following conclusions are quoted from the report: "The key lesson of 1970 is that genetic uniformity is the basis of vulnerability to epidemics. The major question the Committee on Genetic Vulnerability of Major Crops asked was, 'How uniform genetically are other crops upon which the nation depends, and how vulnerable, therefore, are they to epidemics?' The answer is that most major crops are impressively uniform genetically and impressively vulnerable."

The Committee report dealt at length with the related problems of genetic uniformity and vulnerability to diseases and insects in several major species of crop plants, such as wheat, corn, rice, and soybeans. The status of sugarcane was not included in the study. However, most of us who are involved in research, extension, and production of sugarcane are aware of the following facts about the crop.

Because sugarcane varieties constitute clones, all plants within a variety are genetically identical and equally vulnerable to the same pathogens.

Only a few varieties are grown on an appreciable acreage in a region at any time. Consequently, each of these few principal varieties is grown on several thousand acres.

The few varieties which are grown in an area today are closely related in their pedigree or origin and, as a consequence, possess an alarming degree of genetic similarity.

It is apparent from these facts that sugarcane, as produced in Louisiana and Florida, possesses as much genetic uniformity as any other crop plant in the U.S. and, consequently, is more vulnerable to attack by diseases and insects than is desirable. Furthermore, it is highly probable that this genetic uniformity is already having deleterious effects. As long as the genetic uniformity exists there is a constant threat of a disaster comparable to or exceeding that which almost happened to the corn crop.

But a more pressing problem at present is the likely effect that genetic uniformity is having on the longevity of new varieties of sugarcane. If, as is commonly assumed, varieties do undergo declines in vigor and yield through the build up of disease agents and insect pests to which they are particularly susceptible, this varietal decline is hastened by the growing of large acreages of genetically similar varieties. It is probable that the period of usefulness of the variety CP 52-68 in Louisiana was shortened by the production during the same period of NCo 310, a variety which is extremely susceptible to strain H of sugarcane mosaic and was a primary cause of the build up of that strain.

It is also an unfortunate paradox that the more superior, hence successful in terms of acreage, a variety is the shorter is likely to be its longevity, or period of agricultural usefulness. This arises from the fact that production of a genetically uniform variety on a large acreage increases its vulnerability to diseases and insects.

It should be emphasized that the problem cannot be solved by the development and release of varieties that are resistant to currently-serious diseases or currently-occurring races and strains of these diseases. In fact, this is likely to make the problem of vulnerability more critical. Such varieties would be adopted widely, and their production on large acreages would create the genetic uniformity that contributes to vulnerability.

Although it is not the intent of this paper to offer solutions to the problem a few comments on this aspect seem appropriate. For one, there are serious practical obstacles to be cleared. At current support levels, sugarcane breeders cannot develop a larger number than in the past of genetically diverse varieties which are equally superior. Furthermore, sugarcane breeders have no control over the extent to which the varieties they develop and release are grown. Growers show strong preferences for a few varieties regardless of the number available.

However, it is obvious that breeders should devote more attention to the incorporation of greater genetic diversity into their products even though this may not improve the performance of the new varieties. For this reason, the new germ plasm being introduced from the wild species Saccharum spontaneum at the USDA station at Houma should prove extremely valuable for broadening the genetic diversity of sugarcane varieties.

The system for release of new varieties now being followed, based as it is on rigid requirements, has resulted in the release of very few new varieties during the past 20 years. Heretofore this has been considered to be desirable if not essential for a healthy, progressive industry. However, the growing evidence that the high degree of genetic uniformity that results from this policy -- a single variety may be grown on 100,000 to 150,000 acres in the small Louisiana area alone -- makes the sugarcane crop highly vulnerable to losses from diseases and insects and probably shortens the useful life of new varieties. Since it is obviously not feasible to increase the scope of the breeding programs sufficiently to produce an appreciably larger number of highly superior varieties, immediate consideration should be given to some relaxation of standards for the release of varieties in an effort to reduce genetic uniformity, hence the vulnerability of the crop.

Finally, it appears probable that the most effective, perhaps the only feasible, means for reducing greatly the genetic uniformity of the sugarcane crop in any region is through the deliberate incorporation of genetic diversity within varieties. By this I refer to mixtures of selected clones. The firmly and widely held concept that a mixture of two or more clones is somehow inferior to its component pure clones is not based on either experimental evidence or genetic theory. Admittedly there would be problems created by clonal mixtures, but most of these problems could be solved. It is my firm conviction that research should be started on the comparative performance of pure clones and clonal mixtures. If the performance of the mixtures should prove, as expected, equal to the average of the component clones, serious consideration should be given to the release of such mixtures since they would contain built-in genetic diversity and reduced vulnerability.

FURTHER STUDIES ON SYNCHRONIZATION OF FLOWERING OF SUGARCANE

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ABSTRACT

Synchronization in flowering of the commercial sugarcane clones that flower late, and some Saccharum spontaneum clones that flower early can be achieved by enhancing flowering of the commercial clones or by delaying flowering of the S. spontaneum clones. However, due to some peculiarities in flowering of sugarcane, synchronization could not cover a wide assortment of varieties. Therefore synchronization in flowering was attempted by other treatments. Six commercial sugarcane clones were induced to flower by adjusted photoperiod in winter and spring. Their dates of flowering were delayed and the range of flowering was extended by more than 30 days. This delay and spread of flowering of the commercial clones made possible the crossing of these varieties with 3 S. spontaneum clones which have cold resistance. Three other S. spontaneum clones, selected for such characteristics as mosaic resistance, cold resistance, and borer resistance, were induced to flower by adjusted photoperiod in the fall and winter of 1974. Their dates of flowering of some late flowering commercial clones. First crosses were made between the 3 S. spontaneum clones and some late flowering commercial clones. About 10,000 seedlings were produced from such first crosses. These seedlings will be planted in the field next spring for further evaluation and selection.

INTRODUCTION

The need for widening the genetic basis of our commercial sugarcane varieties is well recognized. Saccharum spontaneum L., with its wide assortment of characteristics, is more promising than any other species of Saccharum for use in improving our commercial varieties of sugarcane.

The narrow genetic basis of our commercial sugarcane varieties is well known (1,17); yet new varieties are still being developed by continuous intercrossing of our older ones. This system of crossing and selection will eventually result in no further variety improvement.

Many sugarcane producing countries have tried to utilize wild germ plasm, especially from S. spontaneum, to transmit to commercial canes such specific characteristics as mosaic resistance (4,8), cold tolerance (3,9), wind resistance (4), drought resistance (2), borer resistance (10), and resistance to water logging (19). Progress in this field of research is quite promising.

The introduction of new germ plasm from S. spontaneum into commercial canes by crossing was difficult at first. The difficulties were associated with the difference in the dates of flowering between S. officinarum and S. spontaneum. This difference sometimes extended from 1 to 5 months depending on the origin of S. spontaneum.

To bridge these differences in flowering time, breeders of sugarcane around the world tried photoperiodic adjustments (5,7,11), light interrupting (12,18) or increase in the light intensity (14).

These efforts were aimed at delaying the dates of flowering of S. spontaneum clones.

In this paper, as in those earlier published (15,16,17), methods are described by which synchronization in flowering of sugarcane was achieved either by photoperiodic adjustments aiming at speeding up or delaying flowering of the commercial clones or speeding up or delaying flowering of S. spontaneum clones. First crosses were made between some commercial varieties and some S. spontaneum clones that possessed mosaic resistance, cold resistance and borer resistance. Seedlings were produced and planted in the field for further evaluation.

MATERIAL AND METHODS

Our collection of wild germ plasm includes 8 clones of S. spontaneum L., some of which have erectness and mosaic resistance, while others are cold resistant or borer resistant. The flowering time of some of these S. spontaneum clones differs from the flowering time of the commercial clones by 1-4 months.

In order to bridge the differences in the flowering times between the S. spontaneum clones and the commercial sugarcane clones, an experiment was conducted in the winter and spring of the

1973-74 season. The purpose of this experiment was to enhance or delay flowering of the commercial clones.

Six commercial sugarcane clones were grown in 10 gallon cans or stovepipes in the greenhouse in the fall and winter of the 1973-74 season. These clones included CP 48-103, CP 52-68, L 60-25, L 62-96, CP 65-357 and NCo 310. By the end of December 1973 some of the stalks had an initial growth of 4-6 exposed joints. Six stalks from each clone were marcotted by wrapping two joints of each in a polyethylene bag filled with a wet mixture of soil and peat moss. Under the warm conditions of the greenhouse roots were developed in about 2 weeks. The rooted stalks then were severed and planted in new stovepipes filled with a mixture of soil, peat moss and river sand. On January 20, 1974 the sugarcane plants grown in stovepipes were placed in a plastic-covered greenhouse under 2 bands of fluorescent lights controlled by an electric time switch. The time switch was adjusted to put the lights on in the afternoon before sunset and off in the evening after sunset, so that the sugarcane plants received 10 hr of natural light and 2 hr 30 min natural and electric illumination. The distance of lights from the leaf canopy was about 25"-35". The light intensity at the top of the leaf canopy was about 250 Lux.

The photoperiodic treatment included 12 hr 30 min from January 20 through March 15, 1974. From March 16 through April 9 the plants were given an inductive natural photoperiod. On April 10, 1974 the plants were taken out of the greenhouse and placed on carts for continuation of the treatment in two of the photoperiod houses. The photoperiodic treatment in the photoperiod houses included 12 hr 30 min for 30 days. Afterwards, on May 10 the photoperiodic treatments changed so that the plants in one of the houses received 11 hr 30 min treatment while the plants in the other photoperiod house were given 12 hr 50 min photoperiodic treatment. The duration of these treatments extended until flowering. The dates of flowering for each variety and treatment were taken.

Eight *S. spontaneum* clones were grown in the greenhouse in 10 gallon cans in the fall and winter of the 1973-74 season. On April 15 they were taken out of the greenhouse and tied up in racks for protection from the wind. These plants were watered daily and received natural photoperiod until flowering. The dates of flowering of these clones were recorded.

In order to make crosses between the sparsely flowering clones of *S. spontaneum* and some late flowering commercial clones a photoperiodic experiment was conducted in the fall and winter of 1973-74 season. Three *S. spontaneum* clones were given photoperiod treatments in the fall and winter of 1973-74 season. These included Tuc. 401, SES 205A, and Tainan 96. The photoperiodic treatments started on October 1, 1973 and continued through February 1, 1974. They included 9 hr 30 min of natural light and 3 hr 30 min natural and electric illumination for 90 days. Then half of the plants were moved to the back section of the greenhouse and exposed to natural light for 30 days while the other half were exposed to 10 hr of natural light and 4 hr natural and electric illumination for 30 days. First crosses were made between these clones and some late flowering commercial clones and seedlings were produced. The dates of flowering of the 3 *S. spontaneum* clones and the late flowering commercial clones were recorded. The late flowering commercial clones included CP 57-526, NCo 310 and CP 65-350.

EXPERIMENTAL RESULTS

The dates of natural flowering of 8 *Saccharum spontaneum* clones are shown in Table 1. One of these clones flowered at the beginning of June, three in August, two in September and two in November.

Table 1. Characteristics and dates of natural flowering of 8 *Saccharum spontaneum* L. clones at Baton Rouge, Louisiana in 1974.

Clone	Economic characters	Dates of flowering
US 56-15-8	Mosaic resistant	November 1 - December 10
Tucuman 401	Cold resistant	November 5 - December 15
US 60-4-6	Cold resistant	June 9 - July 2
US 61-2-1	Cold resistant	August 10 - September 2
SES 205A	Cold resistant	August 15 - September 2
SES 278	Borer resistant	August 31 - September 25
Tainan 96	Borer resistant	September 15 - October 5
Mandelay	Cold resistant	September 10 - October 4

The dates of first flower emergence in 6 commercial sugarcane clones, induced to flower by standard photoperiod treatment of 12 hr 30 min from May 15 through September 15, are shown in

Table 2. Flowering in these clones began in September and October. By comparing Tables 1 and 2 it is apparent that the dates of flowering of commercial clones coincided only with the dates of flowering of 4 S. spontaneum clones. The other 4 S. spontaneum clones flowered earlier by 1-3 months.

Table 2. Dates of flowering of 6 commercial sugarcane clones induced to flower by a standard photoperiod treatment* at Baton Rouge in 1974.

Clone	Dates of first flower emergence
CP 48-103	September 20
CP 52-68	September 15
L 60-25	September 18
L 62-96	October 2
CP 65-357	October 5
NCo 310	October 8

* Photoperiod treatment included 12 hr 30 min from May 15 through September 15, 1974, followed by natural photoperiod from September 15 to flowering.

To cause the dates of flowering of these early flowering S. spontaneum clones to coincide with the dates of flowering of the later flowering commercial sugarcane clones an experiment was made aiming at speeding up the flowering of the commercial clones. The results are shown in Table 3. The data in this table show that 4 commercial clones began flowering in June and 2 in July, by photoperiod treatment A. On the other hand 3 commercial clones began flowering in July and 3 in August, by photoperiod treatment B. By comparing the dates of flowering of the commercial clones in Table 3 with the dates of flowering of the S. spontaneum clones in Table 1, it can be seen that the date of flowering of the early flowering S. spontaneum US-60-4-6 coincided with the dates of flowering of 2 commercial clones. Furthermore the dates of flowering of 3 commercial clones coincided with the dates of flowering of 5 S. spontaneum clones, making crossing between them possible.

Table 3. Effect of photoperiod treatments* on the dates of flowering of 6 commercial sugarcane clones at Baton Rouge in 1974.

Clone	Dates of first flower emergence		No. days flowering delayed by photoperiod B
	Photoperiod A	Photoperiod B	
CP 48-103	June 28	July 31	33
CP 52-68	June 12	July 9	27
L 60-25	June 5	July 10	35
L 62-96	June 30	August 1	32
CP 65-357	July 2	August 5	34
NCo 310	July 10	August 15	36
Average			33

*Photoperiod A included inductive photoperiod treatment for 110 days followed by noninductive photoperiod treatment of 25 to 60 short-days.

Photoperiod B included inductive photoperiod treatment for 110 days followed by noninductive photoperiod treatment of 60-96 long days.

The dates of flowering of 3 sparsely flowering S. spontaneum clones are shown in Table 4. These clones flowered by adjusted photoperiod treatment during the fall and winter of 1973-74 season from January 20 through March 1st. At that time usually no commercial canes are available for crossing. However 3 late flowering commercial clones were induced to flower by special treatment. The dates of flowering in these clones are shown in Table 5. The dates of flowering of the 3 commercial clones coincide with the dates of flowering of the S. spontaneum clones in Table 4.

The number of seedlings produced from 10 first crosses involving commercial sugarcane clones and S. spontaneum clones is shown in Table 6.

Table 4. Effect of photoperiod treatments* on the dates of flowering of 3 Saccharum spontaneum L. clones at Baton Rouge in 1973-74.

Clone	Characteristics	Dates of first flower emergence		No. days flowering delayed
		Photoperiod A	Photoperiod B	
Tucuman 401	Cold resistant	January 28	March 1	32
SES 205A	Mosaic resistant	January 20	February 22	31
Tainan 96	Borer resistant	January 26	February 28	33
Average				32

*Photoperiod A includes 13 hr inductive photoperiod treatment from October 1, 1973 through January 1, 1974, followed by 30 short days.

Photoperiod B includes 13 hr inductive photoperiod for 90 days, followed by 30 long days.

Table 5. Dates of flowering of 3 late flowering sugarcane commercial clones induced to flower by special treatments*.

Clone	Characteristics	Dates of flowering
CP 57-526	Cold resistant	February 20 - March 28
CP 65-350	Mosaic resistant	February 25 - March 20
NCo 310	Borer resistant	March 1 - March 30

*Treatments included standard inductive photoperiod treatments from May 15 through September 15. After September 15 natural photoperiod was given throughout the winter of 1973-74. Then on February 1, 1974 canes were moved into greenhouse.

Table 6. List of first crosses made and number of seedlings produced at Baton Rouge, Louisiana in 1974 involving Saccharum spontaneum L. clones and commercial clones.

Cross no.	Parentage	No. seedlings
1	L 60-25 x US 60-4-6	576
2	CP 57-526 x SES 205A	240
3	NCo 310 x SES 278	1,750
4	L 60-25 x US 61-2-1	1,250
5	CP 48-103 x SES 278	850
6	CP 52-68 x Tainan 96	1,850
7	CP 65-357 x Tuc. 401	650
8	L 62-96 x Tainan 96	1,100
9	CP 65-350 x SES 205A	1,050
10	L 65-69 x SES 205A	1,200
	Total	10,516

DISCUSSION

Flowering of sugarcane under controlled photoperiodic conditions is a long process which may take more than 4 months for completion; however flowering in sugarcane under winter and spring photoperiodic conditions may take 5-7 months for completion. The longer induction period required under winter and spring conditions in the greenhouse may be attributed to low intensity of light, unequal conditions of temperature inside the greenhouse, unequal elongation due to intensive competition, and probably to other unknown conditions.

The only way to bridge differences by 1-3 months in the flowering time of commercial sugarcane clones and the early flowering S. spontaneum clones is the use of longer induction period for flowering of the commercial sugarcane clones and by speeding up flower emergence by short days followed after flower initiation. The use of long days after flower initiation may delay flowering by an average of 33 days. That enabled crossing of some commercial clones with S. spontaneum clones

flowering later in the summer. S. spontaneum clones flowering later in the fall could be crossed to any commercial sugarcane clones that flower from October through December.

The fall and winter photoperiod induction of flowering is more successful with S. spontaneum clones than with commercial clones. Apparently commercial sugarcane clones may be more sensitive to greenhouse conditions than S. spontaneum clones. Flowering cycles with commercial sugarcane clones are difficult to be completed inside the greenhouse with photoperiodic treatment unless these fractional treatments will continue outside the greenhouse in photoperiodic chambers. In S. spontaneum clones, however, flowering could be completed inside the greenhouse by photoperiodic induction. The early spring flowering of S. spontaneum following the fall and winter induction did not coincide with the flowering of commercial clones because at that time flowering of commercial clones was completed. However, some late flowering commercial clones kept outside the greenhouse with still depressed flower initials did flower inside the greenhouse between February and March when the natural light is more favorable for flower elongation than during the winter months. Apparently such sparse flowering of the commercial clones in the early spring allows only limited interspecific crossing.

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THE SUGARCANE SELECTION PROGRAM
AT UNITED STATES SUGAR CORPORATION

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ABSTRACT

In the search for improved commercial varieties at U.S. Sugar Corporation, clones derived from sexual seed are screened and selections advanced through 4 stages over a period of 9 years. Information on which selection decisions are made advances from a highly subjective nature in seedlings to a more detailed nature in variety trials. This paper deals with how material is handled and the criteria emphasized as selections are advanced through the 4 stages. (1) Single stool seedlings are evaluated in first stubble by a visual assessment of agronomic characters combined with hand refractometer brix of a small juice sample. (2) Lines (single row, unreplicated clonal plots) are screened for brix and agronomic characters in plant cane and restubbling ability in first stubble. (3) In B-plots (1/50 acre, unreplicated plots) juice analyses are made for percent yield of sugar based on cane weight, and weights are taken at harvest which allow calculation of tons sugar produced per acre in plant cane. Agronomic characteristics are considered in plant cane along with restubbling ability in the first stubble. (4) Clones in the variety trial stage (1/50 acre plots, replicated 6 times) are evaluated through plant cane, first, and second stubble crops. Production and agronomic data considered are similar to that in B-plots. At the conclusion of the variety trial stage, appropriate clones are released to the the Agricultural Department of U.S. Sugar Corporation for commercial purposes.

INTRODUCTION

In 1929 the Southern Sugar Company, predecessor of United States Sugar Corporation, began establishing cane breeding stocks and in 1931 the first cross of the breeding program was made (1). Since that time the Corporation has conducted a continuous breeding and selection program. This program has produced such outstanding varieties as CL 41-223, CL 54-336, and CL 54-378. These particular varieties have occupied large acreages on the Corporation plantations. Numerous other varieties developed in the program have occupied smaller acreages while meeting specific needs for earliness and localized environments (2). At present CL 61-5, CL 61-205, and CL 59-1052 are in the early years of commercial production and milling. While we are optimistic about these varieties, their productivity under commercial conditions will determine their ultimate value.

The breeding program is conducted to provide new genetic combinations for the selection program. This paper deals with how material is handled in the selection program as canes are advanced from seed through the following 4 stages over a period of nine years: (1) single stool seedlings, (2) unreplicated lines, (3) unreplicated B-plots, and (4) replicated variety trials.

SEEDLINGS

A series for screening new genotypes is started each year in early February with the planting of true seed in the form of cane fuzz (Table 1). The fuzz is spread on steam sterilized muck in asphalt-coated metal flats which are 14" x 20" x 3-1/2". Enough fuzz is spread (as estimated by germination tests) to give a maximum of 300 seedlings per flat with a limit of 16 g of fuzz per flat. Before covering with a thin layer of finely screened muck soil, the fuzz is sprayed with a mist of benonyl fungicide (methyl 1-(butylcarbamoyl)-2-benzimidazolecarbamate) mixed at 8 oz of material (50% active ingredient) per 100 gallons water. The flats are kept moist in the greenhouse. Usually a large part of the seedlings are emerged in 7-10 days. The seedlings are kept trimmed to a height of about 6 inches to produce sturdier plants. After about 7 weeks growth, the seedlings are transplanted to other flats of steam sterilized muck soil that have been marked with a 96 hole dibbler for uniform spacing. Seedlings are placed outside the greenhouse in mid-April and kept trimmed to about 12 inches to produce sturdier plants. Seedlings are fertilized and sprayed with insecticides as necessary to keep them in healthy growing condition.

About 41,000 seedlings are transplanted to the field in June (Tables 1,2). The profusion of roots allows the entire group of 96 seedlings to be lifted from the flat with the soil attached. The root mat is sliced with a knife to yield cubes of soil with individual seedlings. Plants are set 36 inches apart in rows 11 feet wide. To eliminate the need of irrigation, transplanting is done in moist soil following a rain. Checks are entered every 400 plants. A 40 acre field is occupies. Seedlings, as well as the lines and B-plots which follow, are planted in a warm muck location 1-2 miles south of Lake Okeechobee near Clewiston.

Table 1. A projected sequence of testing in the varietal selection program at U.S. Sugar Corporation for the 1975 series.

Year	Time	Stage	Estimated no. clones
1974-75	Winter	Crossing season	
1975	Feb. June	Plant true seed Seedlings established in field	41,000
1976	Nov. Dec.	Seedlings selected in stubble Lines planted	1,300
1977		Lines evaluated in plant cane	
1978	July Aug.	Lines selected B-plots planted	230
1979		B-plots evaluated in plant cane	
1980	Aug. Sept.	B-plots selected Variety trials planted	35
1981-83		Variety trial evaluated in plant cane, 1st and 2nd stubble. Additional var- iety trials established.	

Table 2. The no. of clones at various stages in the selection program at U.S. Sugar Corporation beginning with the 1965 series¹.

Series	Seedlings		Lines		B-plots		No. in variety trials
	No.	% advanced	No.	% advanced	No.	% advanced	
1974	40,737						
1973	37,420	2.4	909				
1972	52,260	2.5	1,309				
1971	36,756	3.4	1,244	19.4	241		
1969	31,760	3.5	1,106	17.5	193	20.7	40
1968	40,221	3.4	1,388	15.9	221	14.9	33
1967	59,126	3.2	1,917	10.8	207	15.0	31
1966	35,094	4.0	1,388	22.3	309	8.1	25
1965	40,453	1.7	698	32.7	228	18.4	42
$\bar{x}$ 1965-69 series	41,330	3.1	1,299	17.8	231	14.7	34
% of original seedlings, $\bar{x}$, 1965-69 series	100		3.1		0.6		0.082

¹There was no 1970 series.

Seedlings planted in June are ratooned in December to enhance stool development. Selection begins in the first stubble the following November 15 (11 months). The single stool seedlings are evaluated visually for minimum standards for the following criteria: stalk height, stalk diameter, stalk number, and freedom from diseases, cracks, enlarged buds, root lodging, broken tops, and hollow stalks. If a stool merits further attention a small juice sample is extracted at mid-height with a Hawaiian type punch and the brix is determined with a hand refractometer. The selected seedlings are then assigned permanent identification numbers, e.g. CL 61-205. "CL" abbreviates Clewiston, 61 indicates the year the seedling was transplanted to the field, and 205 represents the 205th selection of that series. Of the 41,000 seedlings about 1300 or 3.1% are selected for advancement.

LINES

Seedling selections are planted to lines in late December (Tables 1,2). The lines are single rows 11 ft wide and 35 ft long. Cross alleys are 15 ft. Generally 3 checks are planted in lines representing different types: early maturity, high cane tonnage, and a successful commercial variety. These are planted after each 100 entries. The lines occupy a 20 acre field.

In the plant cane crop the lines are brixed early and late. The early brix is taken in October (10 months) and the late brix in January (13 months). Juice samples are collected from 35 stalks using the core punch method (3), the juice is expressed at 3500 PSI, and the brix is measured with a hand refractometer. The lines are also observed during the plant cane crop for stalk height, stalk diameter, stalk number, and freedom from diseases, cracks, enlarged buds, root lodging, broken tops, and hollow stalks. Observations are supplemented by counts and measurements. Some undesirable clones are eliminated before the late brix. The plant cane is ratooned in February. The restubbling ability of lines is then observed in the spring and early summer.

From the 1300 lines about 230 clones, or 18%, are selected in July based on data collected in plant cane and early first stubble.

B-PLOTS

Selections from lines are planted in B-plots in August (Tables 1,2). B-plots are unreplicated 1/50 acre plots consisting of 4 rows (on 5 ft centers) by 43.6 ft. To minimize competition there are 2 rows skips between plots. Cross alleys are 15 ft. The three checks are entered after each 40 experimentals.

The plant cane grows through the winter. Then, early and late juice analyses are conducted the following year using the core punch method (3). In October (14 months) core punches are taken from 75 stalks from an outside row. The juice is expressed and brix taken in the field. Juice is preserved with lead subacetate and taken to the laboratory where polarity is determined after clarification. Percent sucrose in the juice is determined and subsequently % yield of 96° sugar is calculated using up to date mill factors. A medium fiber value is used for experimentals. Percent yield refers to the sugar extracted per weight of cane. Juice analyses are conducted again in January (17 months) using about 75 core punches from the center rows. In February the plots are harvested by hand cutting and the outside rows are discarded to reduce border effects (4). The middle rows are weighed with a tractor mounted grapple and scale. Tons cane per acre and tons sugar per acre are then calculated.

During the season clonal characteristics such as stalk height, stalk diameter, stalk number, and leaf attachment are observed. Freedom from diseases, cracks, protruding eyes, hollow stalks, and root lodging is noted. Restubbling ability is evaluated in the spring and summer.

Production data and agronomic observations in the plant cane crop together with restubbling give a basis for selecting clones to advance to variety trials. Of the 230 clones in B-plots, about 35, or 15%, are advanced.

VARIETY TRIALS

Variety trials of selections from B-plots are planted each year in a warm muck location 1-2 miles south of Lake Okeechobee near Clewiston (Tables 1,2). Plots are planted in September and are 1/50 acre as described in B-plots, but with 6 replications. Each trial contains three checks. Data are taken in the plant cane, first, and second stubble crops. Juice analyses are conducted early (October) and late (January) and harvest is in February, similar to the description in B-plots. In plant cane the early and late analyses are at 13 and 16 months, while in the stubble crops the early and late analyses are at 8 and 11 months. Percent yield of sugar, tons cane per acre, and tons sugar per acre are calculated. Observations for stalk diameter, stalk height, stalk number, leaf stripping, and freedom from diseases, enlarged eyes, hollow stalk, and root lodging are continued.

The most promising clones in variety trials are given additional attention. Those clones which continue to be outstanding are tested for percent fiber for three years. Brittleness is measured with a stalk breaking device. Before leading varieties are released they are screened for their reaction to ratoon stunting disease, mosaic, eyespot (*Helminthosporium sacchari* (van Breda de Haan) Butler), and red rot (*Physalospora tucumanensis* Speg). Worthy varieties may be released to the Agricultural Department of U.S. Sugar Corporation for commercial production based on performance in the initial variety trial, disease reactions, and other considerations.

Variety trials are planted in 4 other locations with a mixture of selections directly from B-plots and clones which are outstanding in variety trials. These additional tests are described as: (1) cold muck, south of Lake Okeechobee; (2) warm muck, southeast of Lake Okeechobee; (3) cold muck, southeast of Lake Okeechobee and (4) sandy soil, south of Lake Okeechobee. These additional tests are planted at a given location every third year so there is only one test at each of these locations at any given time. Outstanding varieties may be released for specific areas or all areas based on performance in these tests.

After varieties are released they are increased and planted in representative fields under commercial conditions by the Agricultural Department of U.S. Sugar Corporation. The acreage which a variety eventually attains depends upon its performance in the commercial plantings.

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SUGARCANE VARIETY TESTING IN A NEW AREA OF LOUISIANA^{1/}

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ABSTRACT

The commercial sugarcane varieties CP 61-37, CP 65-357, L 60-25, L 62-96, L 65-69, and NCo 310 were tested near Natchitoches in northcentral Louisiana, about 60 miles further north than the present limit of commercially produced sugarcane. Estimated yields of the six varieties averaged 25.31 tons per acre and 230.4 pounds of sugar per ton of cane. These yields compared favorably with the state average. Although CP 65-357 led all varieties in tons of cane per acre, sugar per ton of cane, and sugar per acre, it was not significantly higher than L 65-69, L 62-96, or L 60-25 in sugar per acre. The late-maturing varieties CP 61-37 and NCo 310 produced the lowest yields in tons per acre and sugar per acre. Results of this experiment suggest that sugarcane can be grown north of the commercial sugarcane area in Louisiana.

INTRODUCTION

The Louisiana sugarcane industry is presently located in the southeastern, southcentral, and central part of the state. The area occupied by sugarcane for sugar production in Louisiana today is basically the same that Stubbs described in 1923 (6). The acreage occupied by the sugar industry has changed little in spite of the removal of sugarcane acreage restrictions in 1972. From 1972 to the present time, about 350 thousand acres have been devoted to sugarcane production in Louisiana. Land usage is fixed in the sugarcane production area, and any expansion of the industry must be done in the western or northern areas of the state.

Sugarcane growers in Avoyelles Parish, the most northern of the sugarcane-growing parishes, consistently produce higher net tons of cane per acre than most south Louisiana parishes (1,2). Sugarcane production can possibly be expanded further up the Red River area into north Louisiana. The potential for high sugarcane yields exist in the Red River area due to very fertile soils and a low incidence of sugarcane mosaic virus disease. Sugarcane in the Red River area is also less vulnerable to hurricanes, because storms moderate after moving inland. Although sugarcane in the northern area is more likely to experience cold damage, lower post-freeze temperatures may prolong the keeping quality of damaged cane.

Sugarcane variety testing currently conducted at 14 locations in all sugarcane producing areas and on all soil types indicates the wide adaptability of varieties now being tested. The breeding program is producing high-yielding varieties with improved cold tolerance (4). Current commercial varieties are high in sucrose and early-maturing, and they should be better adapted to early harvesting in the new area than varieties in the past.

An experiment was established in the Red River area near Natchitoches to determine the adaptability of new varieties to a potentially new sugarcane-producing area in Louisiana. The new test site is located about 60 miles north of the commercial sugarcane growing area in Louisiana.

EXPERIMENTAL TECHNIQUES

Sugarcane was planted in a clearing between established pecan trees on October 11, 1973. A randomized complete block design with 6 replications was used. Each of the 3-row plots covered an area 18 ft wide by 25 ft long with a 4-ft pathway (0.012 acre). Six commercial varieties, CP 61-37, CP 65-357, L 60-25, L 62-96, L 65-69, and NCo 310, were used in the experiment. Progeny of seed cane treated with hot air for the control of ratoon stunting disease came from the Houma Sugarcane Laboratory. The plots were planted at the rate of 2 stalks with a 10% lap.

The established plots were fertilized with 100 lb per acre of nitrogen in the form of nitrogen in the form of ammonium nitrate during May. The plots were sprayed on June 13 with 3-tert-butyl-5-chloro-6-methyluracil (terbacil) at about 0.67 lb per acre on a 30-in. band for weed control.

Estimated yields of net cane per acre were obtained for each plot by multiplying mature stalk counts taken on December 12, 1974, by the average stalk weight. A 15-stalk sample was cut and

^{1/}Research at this location is done in cooperation with the Louisiana Agricultural Experiment Station.

cleaned from each plot and returned to Houma, where it was weighed and milled. A previous study had shown highly significant correlations between estimated and weighed yields of sugarcane (3). However, that study indicated a higher coefficient of variation in estimating than in weighing the plots, indicating more precision from weighing than estimating.

The 15-stalk samples, in addition to being used for stalk weight determinations, were milled through the Laboratory sample mill for juice quality determinations as described by Legendre (5).

RESULTS AND DISCUSSION

Table 1 shows the results of the variety test. The yield in tons of cane per acre did not differ significantly among the six varieties tested. Estimated yields ranged from 22.06 tons for NCo 310 to 28.54 for CP 65-357. Considerable variation was noted in mature stalk counts from plot to plot, and this variation contributed to the lack of significance in yield between varieties.

Table 1. Yield of six varieties tested on Melrose Plantation in northcentral Louisiana during 1974.

Variety	Tons of cane per acre	Sugar per ton of cane ^{1/}	Sugar per acre ^{1/}
	Tons	Pounds	Pounds
CP 65-357	28.54	246.4 a	7032 a
L 65-69	28.02	223.7 b	6269 ab
L 62-96	25.13	242.1 a	6084 ab
L 60-25	25.75	234.0 ab	6025 ab
NCo 310	22.06	226.2 b	4990 bc
CP 61-37	22.38	210.0 c	4699 c
	NS		

^{1/} Means followed by the same letter are not significantly different at the 5% level of probability according to the Duncan multiple range test.

CP 65-357, numerically, produced the highest yield in sugar per ton of cane, but the yield was not significantly different from that of L 62-96 and L 60-25. Numerically, CP 65-357 led all varieties in sugar per acre, but it was not significantly higher than L 65-69, L 62-96, or L 60-25.

Yield response for most varieties compared favorably to results obtained in outfield tests (4). In outfield test, CP 65-357 has consistently outyielded all varieties in sugar per acre. However, in outfield tests, CP 61-37 has consistently outyielded most varieties in tons of cane per acre; therefore, more information is needed to determine the adaptability of various varieties to the new area.

CONCLUSION

Yield results from the plant cane and observations of the stubble suggest sugarcane can be successfully grown north of the present sugarcane-growing area. A sugarcane operation in the new area will need early-maturing, high-sucrose varieties as well as high-yielding, cold-tolerant varieties to be successful. More testing is necessary to determine variety yield reaction to freezing temperatures and drought stress before a final evaluation can be made on the feasibility of sugarcane production in the new area. The lack of cane-processing facilities would hinder development of sugarcane plantations. The nearest mill is about 60 miles away, operating at capacity. Either this mill would have to be enlarged or a new milling facility would be required.

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THE GENETIC BEHAVIOR OF RESISTANCE TO LODGING IN SUGARCANE^{1/}

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ABSTRACT

In 1973, part of a long term study of the genetic behavior of resistance to lodging in sugarcane was conducted. In the experiment, 100 randomly chosen clones from each of 8 biparental crosses were grown in 10-foot clonal plots. Five to 6 replications of the parental clones involved in the crosses were also included in the experiment. Prior to harvest, each plot of the clones of the progenies and the parents was classified for lodging by a system based on a visual estimate of the percentage of severely lodged stalks. Ten stalks were harvested by hand from each clonal plot of the parents and progenies, and average length of stalk was determined. In order to avoid bias, the data for all experimental clones with mean stalk length less than 6 feet were omitted from the study. Although the results can only be considered as preliminary since they involve only one year, some appear to be of value and interest. This conclusion is based on the fact that the parental varieties grown as controls behaved as they had previously in long-term field experiments in respect to lodging. The results confirm those of other workers that resistance to lodging is a quantitative character influenced strongly by the environment. However, its behavior was not that of a typical quantitative character. For one difference, the populations of the progenies derived from the 8 crosses did not fit a normal curve. There was no tendency for a modal class to occur near the mean. Also, although in the progenies of 5 crosses the mean was intermediate between the parents, wide deviations from this occurred in the other 3 crosses. It was apparent, however, that the lodging behavior of the parents was transmitted in some degree to the progenies of crosses. As evidence of this, the progenies of the 8 crosses differed greatly in their means and distributions. Crosses involving one of the 2 erect parental varieties CP 52-68 and CP 66-346 had the highest percentage of erect clones while the progeny from a cross between 2 non-erect varieties, CP 61-37 and L 62-96, had the highest frequency of severely lodged clones. However, 2 crosses in which the erect variety CP 65-357 was a parent contained a surprisingly low percentage of erect clones, suggesting that all erect varieties may not prove to be valuable sources of germ plasm for resistance to lodging.

INTRODUCTION

Hicks (3) found, after surveying the Louisiana sugarcane growers in 1972, that they considered harvestability the number one desirable varietal characteristic.

Although Hebert (2) found significant correlations for stalk erectness between single stools and clones derived from them, they tended to be low and, therefore were considered unimportant. He concluded from his data that rigid selection for erectness either in the single stool stage or among clones in one season would be ineffective.

Morrill-Olavarrieta (4) found a correlation of .64 for erectness between single stool planted seedlings and their respective 5-foot plant cane clonal plots. However, he considered it was not high enough to allow selection from one crop and concluded that lower minimum selection standards should be practiced initially to allow inclusion of more genetically variable types.

Skinner (5) wrote in 1971 that, unlike the economically important characters which are mainly quantitative in nature and continuous in expression under normal environmental conditions, a threshold character such as lodging regularly shows discontinuous expression but maintains an underlying continuous variability.

Breaux (1) concluded that selection for erectness should be conducted in the early test stages for clones that remain erect under normal conditions, but he found that this was not effective for sorting out varieties that would remain erect under conditions conducive to severe lodging.

In 1972, research was begun on several aspects of the genetic behavior of lodging in sugarcane. The principle objectives of the investigation are: a) to develop and evaluate a new system for classifying clonal plots based on the percentage of stalks which are lodged; b) to determine the

^{1/} The assistance of the American Sugar Cane League, members of the U. S. Sugarcane Laboratory, Houma, La., and the Louisiana Agricultural Experiment Station, Baton Rouge, La. made this research possible.

genetic behavior of lodging; c) to determine associations between stalk erectness and other important economic characters. This paper is a preliminary report dealing with the genetic behavior of the resistance to lodging in sugarcane.

MATERIALS AND METHODS

The materials used in this study included the unselected progenies of 8 biparental crosses. The parental varieties of the 8 crosses are shown in Table 1.

Table 1. Parentage of the 8 biparental crosses.

Cross no.	Parentage
1	CP 52-68 x CP 48-103
2	L 61-67 x CP 62-258
3	CP 61-37 x L 62-96
4	L 60-25 x CP 57-614
5	CP 65-357 x CP 62-258
6	L 60-25 x CP 66-346
7	CP 52-68 x L 65-69
8	CP 65-357 x L 65-69

Crosses 1 through 4 were grown and classified for lodging in one experiment as first and second stubble clonal plots during the period of 1972-73. Crosses 5 through 8 were grown and classified in an additional experiment as plant cane and first stubble clonal plots in 1973-74.

The materials were obtained from the U. S. Sugarcane Laboratory in Houma, La. In the fall of 1970, 100 single stools were chosen from each of the first 4 crosses. The single stools were selected at random except for the requirement that each have at least 4 stalks and that they be free of visible symptoms of mosaic. A 10-foot unreplicated clonal plot was established from each of the 400 single stools at the St. Gabriel branch of the La. Agricultural Experiment Station. Five or 6 replications of each of the 8 parental varieties were scattered among the plots of the 400 experimental clones. In the fall of 1972, crosses 5 through 8 were selected and established in 10-foot clonal plots in the same manner as for crosses 1 through 4.

In 1973, the clonal plots were classified by a system that was described in a paper presented at the 1974 Joint Meeting of the ASSCT (6). This system consisted of a visual estimate for each plot of the percentage of stalks which were lodged, with lodged stalks defined as those which lean from the completely upright or vertical position by at least 45°. The new rating system was used in 1973 to classify each clonal plot of both the second stubble crop of crosses 1 through 4 and the plant cane crop of crosses 5 through 8, and in 1974 for the first stubble crop of crosses 5 through 8.

Unfortunately, the 1974 results were influenced strongly by the hurricane that occurred in September. Because the lodging behavior of the parental varieties following the hurricane was not typical of their behavior in non-hurricane years and differed from their relative behavior in 1973, the 1974 data was not included in this report. Instead, the paper is limited to data obtained in 1973, a non-hurricane year.

Since the experimental clones in the progenies of the 8 crosses were unselected, some were too short to be of potential value in a breeding program. Because of the possibility that these unacceptably short clones might tend to be more resistant to lodging due to their short stature, the data included in this report are limited to the clones with mean stalk length of 6 feet or greater.

RESULTS AND DISCUSSION

Data on lodging, expressed as a percentage of severely lodged stalks, were obtained for the parents and the experimental clones from both the 4 crosses in the second stubble crop (Table 2) and the 4 crosses in the plant cane crop (Table 3) in 1973. Although the data used are the result of only 1 year, the lodging behavior of the parental varieties closely agreed with previously reported behavior. The varieties in both experiments ranged in lodging behavior from resistant to susceptible. The 4 varieties CP 52-68, CP 57-614, CP 66-346, and CP 65-357 were the most resistant to lodging whereas the 4 varieties CP 61-37, L 62-96, L 60-25, and L 65-69 were the most susceptible. The 3 varieties CP 48-103, L 61-67, and CP 62-258 exhibited intermediate behavior in regards to lodging.

Table 2. Frequency distributions for % lodged stalks for the parents and the experimental clones from 4 crosses in the second stubble crop, in 1973.

Population	No. of clones in each of the following % erectness classes											Mean
	0	10	20	30	40	50	60	70	80	90	100	
CP 52-68	5											00.0
CP 48-103	1	1	1		1	1						24.0
Progeny	59	6	4	4	3	5	3	5	1	1	2	16.7
L 61-67	2			1	1	1						24.0
CP 62-258	3		1		1							12.0
Progeny	34	2	6	4	9	2	7	6	8	3	5	34.6
CP 61-37					1		1	3				62.0
L 62-96					1	1	1	1			1	64.0
Progeny	16	3	1	5	5	7	5	6	6	12	10	53.0
L 60-25						1			1	1	2	84.0
CP 57-614	3	1		1								8.0
Progeny	24	1	7	6	2	7	7	9	5	7	13	47.1

Table 3. Frequency distributions for % lodged stalks for the parents and the experimental clones from 4 crosses in the plant cane crop, in 1973.

Population	No. of clones in each of the following % erectness classes											Mean
	0	10	20	30	40	50	60	70	80	90	100	
CP 65-357	4		1							1		18.3
CP 62-258	2				1	2				1		38.3
Progeny	32	1	2	6	1	2	5	9	5	1	12	39.3
L 60-25	1	1			2	2						31.7
CP 66-346	6											00.0
Progeny	52	1	3	3	6	7	3	1	4		3	19.5
CP 52-68	6											00.0
L 65-69						1	3	2				61.7
Progeny	66			3	1	3	7	3	2	1	3	16.4
CP 65-357	5								1			13.3
L 65-69							2	4				66.7
Progeny	40	1	3	5	3	11	6	7	3	7	6	34.9

It is apparent, as other workers have indicated, that inheritance of lodging resistance is quantitative in nature. The frequency distributions exhibited certain features that are typical of quantitative traits. Both the replications of the parental clones and the randomly selected experimental clones did not occur in a few qualitative classes but occurred in a large number of continuously varying classes, indicating a strong environmental influence.

However, there were certain traits uncharacteristic of a normal distribution and atypical of a quantitative character. For all crosses, the modal class did not occur near the progeny mean and the population did not fit a normal curve.

In 5 of the crosses the progeny mean fell below the mean of the least resistant and above the mean of the most resistant parent. However, 2 crosses had progeny means above both parent means while 1 cross had a progeny mean below both parent means.

The progeny mean was above the arithmetic average of the parents in 5 of the crosses, while in 3 crosses the progeny mean fell below the arithmetic parental average.

For 6 of the crosses there was a larger percentage of experimental clones which occurred below rather than above the arithmetic average of the 2 parents and ranged from 54 to 78% of the progenies. Conversely, 2 of the crosses had a larger percentage of the progeny, 55 and 58%, which occurred above rather than below the arithmetic average of the 2 parent means.

The inconsistency of these traits among the crosses make these progenies atypical of a quantitative character. Nevertheless, it is evident from this variation in progeny means and distributions that the lodging behavior of the parents was transmitted in some degree to the segregates of the crosses.

The class which contained the most experimental clones was the 0% erectness class, and it contained from 21 to 74% of the progenies. It is probable, however, that a large number of these erect segregates escaped lodging and do not possess genotypes for erectness that their classification implies. Parental behavior suggests that, although highly resistant clones would be in the 0% erectness class, some susceptible clones, because of only limited data, would also occur in the 0% erectness class.

In only one cross were there any clones numerically lower than the lowest replication of the most resistant parent. The cross, CP 61-37 x L 62-96, had 33% of its progeny below the range of the most resistant parent.

On the other hand, there were 6 crosses which possessed segregates numerically higher than the highest replication of the least resistant parent. The frequency of segregates above the range of the least resistant parent of these 6 crosses varied from 7 to 34%.

For all crosses the frequency of clones exhibiting severe lodging--clones possessing from 59 to 100% lodged stalks--varied from 18 to 61%.

Crosses involving any of the 3 erect parental varieties CP 52-68, CP 66-346, and CP 65-357 contained the highest percentage of erect segregates in contrast to crosses involving the lodging susceptible parental varieties. The 2 crosses involving CP 52-68 and the cross involving CP 66-346 had 63, 74, and 63% of their respective progenies in the 0% erectness class. In contrast, the cross between 2 of the most lodging susceptible varieties, CP 61-37 and L 62-96, had only 21% of its progeny in the 0% erectness class.

It is also evident that not all erect varieties are equally valuable in transmitting lodging resistance to their offspring. The 2 crosses having the erect variety CP 65-357 as a parent contained an unexpectedly low percentage of erect progeny. In these crosses, only 42 and 43% of the respective progenies occurred in the 0% erectness class. More surprisingly, the cross which included the erect variety CP 57-614 had only 27% of its progeny classified in the 0% erectness class.

Before estimates of the heritability of lodging resistance, as measured by clonal repeatability, can be obtained, additional data are required. However, the fact that in all of the 11 plots grown of the erect variety CP 52-68 there was no lodging suggests that in 1973 under the conditions of these experiments resistance to lodging of the type found in CP 52-68 could have been selected with moderate effectiveness in small clonal plots.

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BREEDING BEHAVIOR OF SUCROSE CONTENT IN THE PARENTS
AND THE PROGENY OF
EIGHT BIPARENTAL SUGARCANE CROSSES

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ABSTRACT

A research problem was conducted with one of its objectives to determine the inheritance of sucrose content in sugarcane. Eight crosses in which the parents differed in sucrose level were selected. A total of 100 single stools from each cross was chosen at random and was planted in 10-foot clonal plots along with 6 replications of each of the parents. Clonal plots of 4 of the crosses were harvested 4 times during 1971-1973. Plots of the other 4 crosses were harvested twice during 1973-1974. The sucrose percentage for each of the experimental and parental clones was determined for each harvest. Analysis of variance indicated significant differences in sucrose percent among the 11 varieties used as parents of the 8 crosses. Using the HSD test, it was determined that 6 of the 8 crosses had parents which were significantly different in sucrose content. Sucrose percent exhibited traits normally expressed by quantitative characters, such as a large number of classes which were continuously distributed. However, there were several aspects concerning the inheritance of sucrose content which were atypical of most quantitative characters. Unlike typical quantitative characters, the progenies of the 8 crosses were centered below the average sucrose of the 2 parents of each cross. As an average of the 8 crosses there was 74% of the progeny which fell below the average of the 2 parents while only 26% occurred above this value. Results indicated that epistasis probably occurred causing genes for low sucrose to express themselves among the segregates of all crosses. As an average of the 8 crosses there was 25% of the progeny which occurred above the range of the high sucrose parent and below the range of the low sucrose parent, indicating that transgressive segregation occurred. However, only 2% of these transgressive segregates occurred above the range of the high sucrose parent. It was apparent from the data that crosses in which one or both parents had high sucrose produced the largest frequencies of high sucrose clones. However, the data indicated that a physiological ceiling on sucrose percent may exist as no clones exceeded 19.3% among the progenies of the 8 crosses. The data show that selection for high sucrose clones should begin at as early a selection stage as possible in order to increase the frequency of high sucrose clones in later stages. An estimate of heritability for clonal plots was .85 as obtained from the average of the correlation coefficients for the 8 crosses between sucrose percent of each harvest and the average sucrose percent of all harvests. Selection based on one sucrose analysis would have been very effective in selecting the highest sucrose clones for the 8 crosses.

The assistance of the American Sugar Cane League, members of the U.S. Sugarcane Laboratory, Houma, Louisiana, and the Louisiana Agricultural Experiment Station, Baton Rouge, Louisiana, made this research possible.

THE SELECTION OF HIGH SUCROSE CLONES
FROM SINGLE STOOL BRIX DATA^{1/}

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ABSTRACT

A research problem was conducted with one of its objectives to determine the effectiveness of selection for high brix in the single stool stage in obtaining high sucrose experimental clones. Eight crosses in which the parents differed in sucrose level were selected. In 1970, a total of 100 single stools from each of four crosses was chosen at random and the hand refractometer brix of each single stool was determined. In 1972, the same procedure was followed for the four additional crosses studied. Each of the 800 single stools, along with six replications of each of the 16 parental clones, was planted in 10-foot clonal plots. During the period 1971 to 1973, four harvests were made from each clonal plot of crosses 1 through 4. In the period 1973 to 1974, each clonal plot of crosses 5 through 8 were harvested twice. The sucrose percentage of each clone was determined for each of the harvests. In determining the effectiveness of selection, the association between brix in single stools and the sucrose of the clones derived from them for each harvest and the mean sucrose of all harvests was studied by calculation of correlation coefficients. The correlation coefficients between refractometer brix and the mean sucrose of these resulting clones as an average of all harvests ranged from .56 to .62 for crosses 1 through 4 and from .36 to .64 for crosses 5 through 8. All eight correlation coefficients are positive, highly significant, and indicate at least a moderate degree of association. Thus, selection for high brix among single stools would have been moderately, but not highly, effective in obtaining high sucrose clones. The relative frequency of high sucrose clones (15.5% sucrose or higher) was calculated for the entire progeny and for a selected progeny containing single stools in the upper 30% for refractometer brix. The relative frequency of high sucrose clones in the entire progeny was only half that of the selected progeny for seven of the eight crosses. Therefore, selection for high brix in single stools could have resulted in doubling the frequency of high sucrose experimental clones in these seven crosses. It was concluded that a selection rate of approximately 30% of the single stools based on refractometer brix would have been most feasible. The fact that selection in single stools for high brix is not completely effective emphasizes the need for large populations of single stools to begin the program and large numbers of clones in first line trials.

INTRODUCTION

There is a continuous demand for new varieties of sugarcane in the Louisiana sugar industry. It is the goal of the sugarcane breeder to develop and select varieties which will increase the production of sugar per acre. For this reason, selection of high sucrose clones is one of the major objectives of the breeding program.

Selection for higher sucrose varieties probably began when primitive man selected and maintained softer and sweeter clones for chewing purposes (1). From this point in time, the techniques used in the selection of high sucrose clones have improved but have often been evaluated to insure efficiency of the procedures.

In 1928, Verret and Manglesdorf (10) described the use of the hand refractometer to sample standing cane rapidly for brix, which had been shown to be highly correlated with quality ratio. In 1933, McIntosh (8) found a positive, significant correlation between percent sucrose of single stools and their subsequent vegetatively propagated clones.

Lennox (7) in 1935 found that hand refractometer brix was strongly associated with recoverable sucrose, with correlation coefficients ranging from $.875 \pm .006$ to $.974 \pm .001$ in different seedling populations.

Christianson (4) in 1937 obtained a correlation coefficient of .9022 between refractive solids of sampled internodes and polarization of the cane juice in 74 tests.

Hebert (6) found a correlation coefficient of .587 between brix of 896 seedlings and brix of their vegetatively propagated clones.

^{1/}The assistance of the American Sugar Cane League, members of the U.S. Sugarcane Field Laboratory, Houma, La., and the Louisiana Agricultural Experiment Station, Baton Rouge, La., made this research possible.

Breaux et al (2) found correlation coefficients of .49 and .43 between brix of single stools and sucrose of 8-foot plots established from these single stools in two series of crosses at the Louisiana Agricultural Experiment Station.

Daniels (5) in 1959 indicated that refractometer brix was a reliable guide in selecting original seedlings and brix of canes in 20-foot single lines plots varied between .54 and .83.

These and other researchers have concluded that selection in the individual stool for brix is effective to some degree in obtaining sugarcane varieties with high sucrose content.

Then in 1970, Breaux and Dunckelman (3) compared a two-stalk sample of cut cane for the refractometer brix analysis to the standard procedure of using five-stalk samples of standing cane. It was concluded that this simplified refractometer brix sampling technique in single stools was faster and more effective than the old method, especially since the two-stalk sample could then be used to plant the first line trials.

Because of the importance of hand refractometer brix in the present Louisiana breeding programs, an experiment was conducted with one of its objectives to determine the effectiveness of selection for hand refractometer brix in the single stool stage in obtaining high sucrose experimental clones.

MATERIALS AND METHODS

The unselected progenies of eight biparental crosses were used in this study. The crosses were chosen on the basis of known differences in sucrose content of the parental clones. The parentages of the eight crosses are shown in Table 1.

Table 1. Parentages of the eight crosses involved in the experiment.

Cross no.	Parentage
1	CP 52-68 x CP 48-103
2	L 61-67 x CP 62-258
3	CP 61-37 x L 62-96
4	L 60-25 x CP 57-614
5	CP 65-357 x CP 62-258
6	L 60-25 x CP 66-346
7	CP 52-68 x L 65-69
8	CP 65-357 x L 65-69

One hundred clones were chosen at random from the first stubble crop of single stools for each cross. Four stalks from each selected single stool were cut, hand cleaned, bundled, and assigned a clonal number. Two hand refractometer-brix readings were made from each bundle. Juice from the middle of the fourth or fifth internode from the base of two stalks was extracted with a Hawaiian-type punch to provide a composite juice sample for one refractometer reading. The mean refractometer brix of each single stool was calculated as an average of the two readings.

The four stalks of each single stool were then used to establish a 10-foot clonal plot at the Louisiana Agricultural Experiment Station, St. Gabriel Farm, along with six replications of each of the parental varieties. Crosses 1 through 4 were chosen, brixed, and planted during the week of September 28 through October 2, 1970. Crosses 5 through 8 were chosen, brixed, and planted during the week of September 25 through September 28, 1972.

Samples from each clonal plot, including the parental varieties of crosses 1 through 4; were collected once in the plant cane crop in 1971, twice in the first stubble crop in 1972, and once in the second stubble crop in 1973. Samples from each clonal plot of crosses 5 through 8 were collected once in plant cane in 1973 and once in first stubble in 1974. For each harvest, a 10-stalk sample was hand cut from each clonal plot and milled to give about 60% juice extraction. Pol readings were then obtained from clarified juice samples and crusher juice sucrose was determined from Schmitz's table (9). The mean sucrose percent for each clone was calculated as an average of all sucrose analyses for each clone.

RESULTS AND DISCUSSION

The data indicated that single stools high in refractometer brix had a moderate tendency to produce clones high in sucrose. The correlation coefficients for the eight crosses, between the mean refractometer brix of single stools and the mean sucrose percent of the clones derived from them, as an average of all harvests, are shown in Table 2.

Table 2. Correlation coefficients between refractometer brix of single stools and average sucrose percent of clones derived from them.

Cross no.	r value
1	.59**
2	.56**
3	.61**
4	.62**
5	.42**
6	.36**
7	.64**
8	.38**

The r values range from .36 to .64 and are positive and all are highly significant. This indicates a moderate tendency for high refractometer-brix single stools to produce high sucrose clones and for low refractometer-brix single stools to produce low sucrose clones.

This can be further evaluated by comparing the mean sucrose percent of the entire progeny of a cross to the mean sucrose percent of a selected progeny of a cross. These values for the eight crosses are shown in Table 3.

Table 3. Mean sucrose percent of the entire progenies and selected progenies derived from high-brix single stools and low-brix single stools.

Cross no.	Mean sucrose percent of		
	Entire progeny	High-brix selected progeny	Low-brix selected progeny
1	12.90	13.64	11.72
2	14.19	14.88	13.29
3	13.92	14.75	12.93
4	14.23	14.89	13.43
5	14.60	15.41	14.06
6	13.92	14.43	13.46
7	13.18	14.16	11.90
8	14.50	15.18	13.82

The high brix selected progenies consist of clones established from the highest 30% of the single stools based on refractometer brix, while the low brix selected progenies consist of clones established from the lowest 30% of the single stools based on refractometer brix. As an average of the eight crosses, the mean sucrose of the high brix selected progenies was .74% sucrose above that of the entire progenies. This shows that, in general, high refractometer brix single stools did produce a progeny of clones that were high in sucrose. The selected progenies derived from low brix single stools produced a mean sucrose .85% lower than the sucrose of the entire progenies of the eight crosses. This shows that, in general, low refractometer brix single stools did produce a progeny of clones that were low in sucrose.

It can be seen in Fig. 1 that there was a very strong association between the mean sucrose content of the parental clones of a cross and the average sucrose of all the clones in the progeny of that cross. A correlation coefficient of .99 was calculated between the mean sucrose percent of the parents and the average sucrose percent of the entire progenies for the eight crosses. This highly significant r value indicates that crosses having the highest sucrose content parents produced the highest sucrose progenies, while the lowest sucrose content parents produced the lowest sucrose progenies.

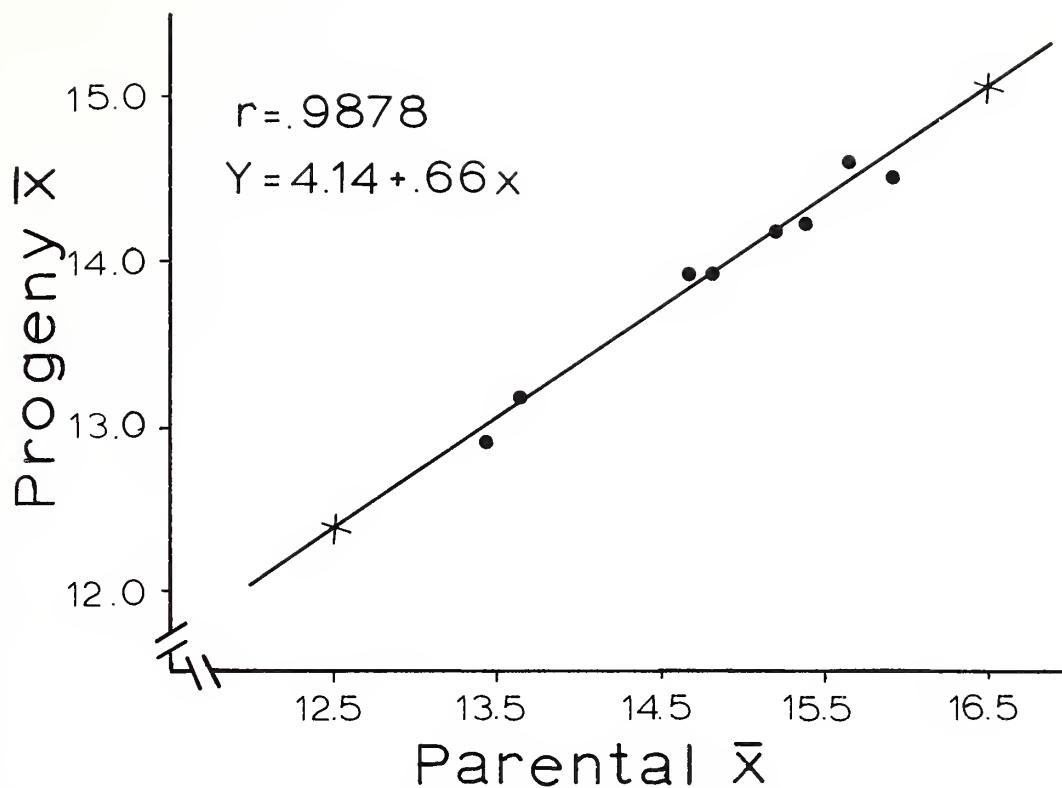


Fig. 1. Relationship between mean sucrose percent of the two parental clones of each cross and the mean sucrose percent of the entire progenies of each cross.

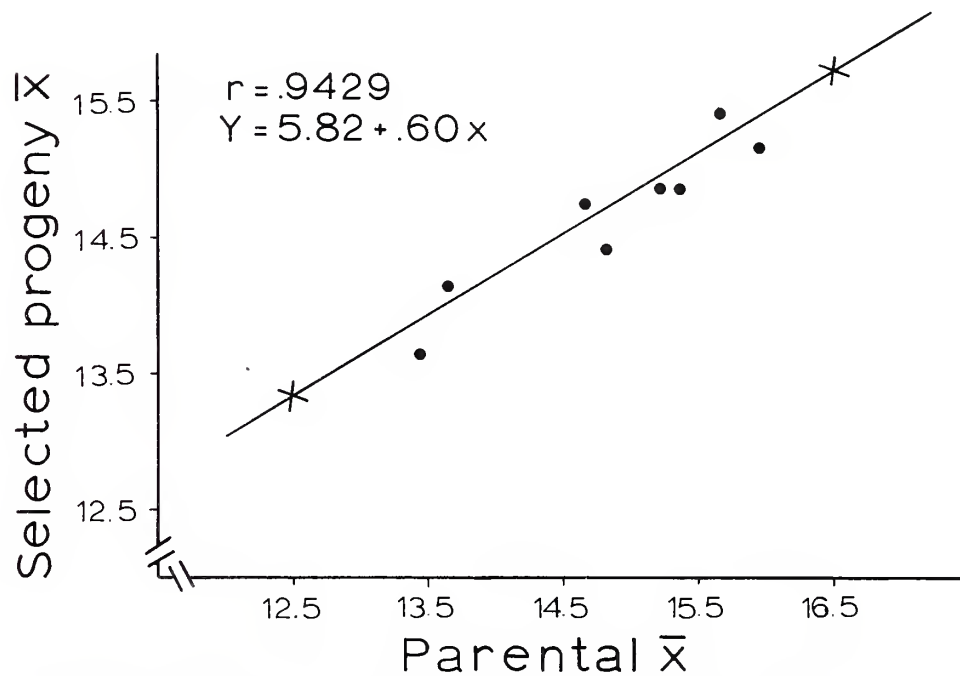


Fig. 2. Relationship between mean sucrose percent of the two parental clones of each cross and the mean sucrose percent of the high brix selected progenies of each cross.

This same very strong association is also seen in Fig. 2, which shows the association between the mean sucrose percent of the parental clones of a cross and the mean sucrose percent of a selected progeny of that cross. These selected progenies of each cross consisted of clones established from the highest 30% of single stools according to refractometer brix. The correlation coefficient of .94 indicates that there was also a very strong tendency for crosses with the highest sucrose parents to produce the highest sucrose selected progenies. It can be seen in Fig. 1 that the average sucrose percent of the entire progenies for each of the eight crosses was lower than the mean sucrose percent of the parents of each cross. However, in Fig. 2, the average sucrose percent of the selected progenies for each of the eight crosses was nearly equal to the mean sucrose percent of the parents of that cross. Thus, there was a marked improvement in the average sucrose content of the selected progenies over the entire progenies of the eight crosses in relation to the sucrose content of the parents used for each cross.

It should also be pointed out that the average sucrose percent of both the entire progenies and the selected progenies of each of the eight crosses could have been predicted very accurately from the average sucrose percent of the two parents of the cross.

The general effectiveness of single stool brix in selecting clones high in sucrose percent indicates that the use of refractometer brix in this preliminary stage would be of some importance. To further evaluate this technique, the actual effect of selection for refractometer brix in single stools on the relative frequency of resulting clones with high sucrose content is shown in Table 4.

Table 4. Frequency of clones with mean sucrose of 15.5% or higher in entire and selected progenies (highest 30% by refractometer brix).

Cross no.	Percent of progeny 15.5% sucrose or higher	
	Entire progeny	Selected progeny
1	7	15
2	16	35
3	16	19
4	15	33
5	31	59
6	10	21
7	4	14
8	28	45

A sucrose level of 15.5% could be considered as high, since in this experiment 15.5% was the level of several clones known to be high in sucrose, such as L 62-96. In Table 4 can be seen the frequency of clones in the entire progeny and in a selected progeny of each cross which were 15.5% sucrose or higher. The selected progenies consisted of clones resulting from the highest 30% of single stools based on refractometer brix for each cross.

In all crosses there was improvement in the frequency of high sucrose clones in the selected progeny over the entire progeny. As an average of the eight crosses, there was a doubling of the frequency of high sucrose clones from 16% in the entire progenies to 30% in the selected progenies. This marked improvement indicates that selection in single stools, based on refractometer brix, would have produced a population of first line trials containing a larger frequency of high sucrose clones in comparison to a population of first line trials produced from single stools selected without the use of brix data.

One very important aspect to be considered would be the number of high sucrose clones that would have been mistakenly discarded because of low refractometer brix in the single stool stage. There were 732 clones in the progenies of the eight crosses and, of these, 118 clones had a sucrose level of 15.5% or higher. Of these 118 high sucrose clones, there were 67 clones, or 57%, which would have been selected in a progeny of clones resulting from the highest 30% of single stools based on refractometer brix. This would have left 51 clones, or 43%, of the high sucrose clones, which would have been lost through selection for high brix in the single stool stage. This can be compared to selection in the single stool stage without the use of refractometer-brix data. With selection in single stools only on the basis of agronomic traits, there would have been only 16% of high sucrose clones from which to select. Using a similar selection rate of 30% of single stools, it can be assumed that 70% of the high sucrose clones would have been lost.

Therefore, the use of refractometer brix in the single stool stage not only increased the frequency of high sucrose clones in the first line trials, but also reduced the number of high sucrose clones which would have been discarded in single stool selection.

The data indicated that a selected progeny produced from a more liberal selection rate of the highest 50% of single stools based on refractometer brix would not be as feasible as a selected progeny produced from the highest 30% of single stools based on refractometer brix. Using the more liberal selection rate, more of the high sucrose clones would be retained with a smaller number being mistakenly discarded because of low brix in the single stool stage. However, the amount of time and work to select, brix, and plant this large number of single stools in relation to the improvement obtained without the use of brix data in single stools would make this selection level impractical.

On the other hand, with a more rigid selection level of the highest 10% of single stools based on refractometer brix, less work and time would be involved in handling the material. However, the number of high sucrose clones mistakenly discarded would be too large in comparison to selection in single stools without brix data.

Therefore, the data indicated that a selection rate of 20-40% would be optimum. Using a selected progeny of clones produced from the highest 30% of single stools based on refractometer brix, the amount of material to be handled would be kept to a minimum while allowing for the largest number of high sucrose clones to be retained in comparison to selection in single stools without brix data.

The data also indicated that the use of only one refractometer reading was just as effective as the mean of two refractometer readings. In terms of correlation coefficients, mean sucrose percent of selected progenies, and effectiveness of selection on high sucrose clones, one refractometer reading was just as effective as the mean of two readings.

The data show that selection in single stools using brix data is not completely effective. This emphasizes the need for large initial populations of single stools as well as for the largest number of resulting clonal plots that would be practical.

The data have shown that use of one refractometer reading from two stalks of each selected single stool could be a useful screening technique in an effort to increase the frequency of high sucrose clones in the resulting clonal plots.

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PURITY AS A SELECTION CRITERION IN SUGARCANE

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ABSTRACT

High purity, which indicates that sucrose comprises a large proportion of the soluble solids in cane juice, is important in cane varieties because it contributes to high sucrose yields and to efficient processing. However, measurement of purity in early selection stages in cane breeding is tedious and costly, and is justified only if selection for high purity significantly improves the sucrose yield of the selected population. We examined purities of varieties in our Stage II, III, and IV variety trials over the past 6 years. During that time, mean purities of test populations did not increase, while there were rather consistent increases in brix and sucrose percentage. In the Florida program, the primary selection criterion has been sucrose yield per acre, and purity data have been used mainly as a tool for selecting high-sucrose varieties. The close correlation between brix and sucrose, averaging about .92, makes it feasible to select Stage II and III varieties on the basis of brix yield per acre, instead of sucrose yield, thereby making purity readings unnecessary. Varietal differences in purity do exist, however, and cannot be ignored in later selection stages. Averaged over six replications, mean purities of 98 varieties in our 1974 Stage III test ranged from 77.5 to 89.4. Using variance and heritability estimates for purity, it can be estimated that, by selecting varieties solely on the basis of high purity and discarding 95% of the population, varieties could be produced averaging 4.1% higher in purity than the unselected population. However, because several traits of greater importance must be considered in variety selection, selection for purity cannot receive much emphasis and the gathering of purity data on Stage II and Stage III plots is probably not justified.

INTRODUCTION

Purity, in sugarcane, is the percentage of dissolved solids in the juice that is sucrose. Since brix is defined as total soluble solids, purity can be defined as the ratio of sucrose to brix. According to Spencer and Meade (1963), purities for most sugarcane varieties fall between 70 and 88%. Nonsucrose soluble solids include glucose, fructose, and other sugars, as well as organic and inorganic salts, proteins, gums, and waxes. Glucose and fructose are degradation products of sucrose. Since the three sugars are readily interconvertible by simple chemical reactions and are always present within the cane plant in dynamic equilibrium, it is easy to envision how the position of the equilibrium, and consequently the juice purity, could be altered by genetic and environmental factors (Hebert and Rice, 1972).

Two considerations make purity important in sugarcane varieties used in commercial sucrose production. First, nonsucrose materials such as glucose, fructose, proteins and waxes, if recovered at all in milling, give lower economic returns than sucrose. Production of these nonsucrose materials requires energy from the plant--energy which, in a better variety, would have been used for sucrose recovery in milling. According to the Winter-Carp-Geerligs formula, each kg of non-sucrose solids retains .4 kg of sucrose, the retained sucrose going into the molasses (Arceneaux, 1935).

In most sugarcane varieties purities are high, with sucrose representing 70-88% of the soluble solids. Thus, a reasonably reliable estimate of sucrose content in cane juice can be obtained by measuring brix. As purities deviate from assumed values, brix measurements become less reliable as estimators of sucrose content.

The fact that high purity is essential in sugarcane varieties does not automatically mean that purities must be scrutinized by breeders at each stage in variety development. To be an important selection criterion, a trait must not only have economic importance, but must also show significant variation from one variety to another.

In this study we examined juice purities of entries in our variety development program. The objective was to determine if purities of entries were sufficiently uniform to allow us to omit purity as a selection criterion in early stages of our variety program, and to use brix as the sole estimator of available sucrose. During October, when juice samples from the selection program are being analyzed, our juice laboratory is not capable of processing as many samples as we wish to study. If purity determinations were omitted, the number of test samples processed could be greatly increased.

MATERIALS AND METHODS

Brix, apparent sucrose, and purity were determined for each entry in Stages II, III, and IV of the Canal Point Sugarcane Variety Development Program for several years. Approximate plot size, replication numbers, and numbers of test varieties per entry are given in Table 1.

Table 1. Description of Stages II, III, and IV in the Canal Point breeding program.

Stage	Approximate no. of test varieties	Plot size (m ²)	No. of reps/ location	No. of locations
II	500	17	1	1
III	100	14	2	4
IV	12	65	4	8

Brix, sucrose, and purity were determined from a 10-stalk sample harvested from each plot between October 15 and October 30 during each year. All data are from the plant crop. Brix was measured by brix hydrometers prior to 1974, but in 1974 a critical angle refractometer manufactured by Electon Machine Corporation was used. In all years, Horne's dry lead was mixed with the raw juice. The juice was then filtered, and the filtrate was evaluated with an automatic polarimeter. Apparent sucrose was obtained from brix and polarization readings by use of Schmidt's Table (Spencer and Meade, 1963). Purity was calculated by dividing brix by apparent sucrose and multiplying by 100.

Genetic advance to be expected as a result of selection for purity in Stage III was calculated from the formula $G_s = K (A) (H)$, as given by Allard (1960). Here K values are taken from standard tables, A is the square root of the phenotypic variance for purity in a Stage III population, and H is the square root of the heritability estimate for purity, derived from analysis of variance. Mean purities of populations that could be obtained from Stage III by selection at various intensities were calculated by adding estimated genetic advances to the population phenotypic mean. These values are given as mean purity (genetic) in Table 2.

Table 2. Juice purity in various sectors of a Stage III population.

Group	Mean purity (observed)	Mean purity* (genetic)
Purest 1%	89.4	88.8
Purest 2%	89.3	88.4
Purest 5%	88.5	87.7
Purest 10%	87.8	87.1
Purest 30%	86.5	85.9
Purest 50%	85.6	85.2
Unselected	83.6	83.6

*Calculations as described in Materials and Methods.

RESULTS AND DISCUSSION

The 98 varieties in the 1974 Stage III variety test, when averaged over six replications, had approximately a normal distribution for purity, with values ranging from 77.5 to 89.4% (Fig. 1).

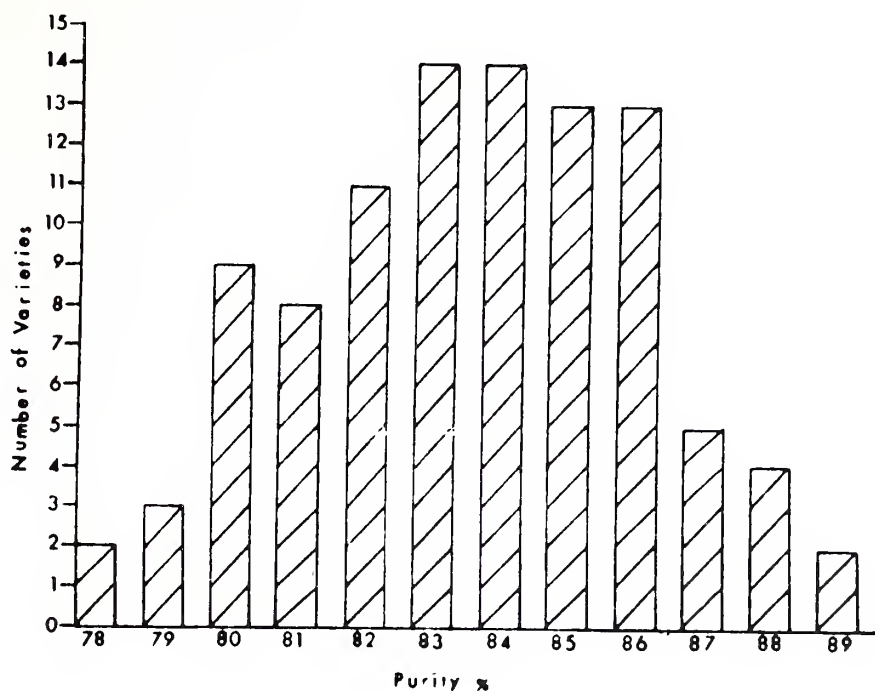


Fig. 1. Distribution of purities of Stage III varieties in 1972.

An estimation of the effectiveness of selection for purity in this population is given by the mean purity of various sectors of the distribution (Table 2). For example, the mean purity of the purest 10% of the test varieties was 87.8%, compared to the overall population mean of 83.6%. In any test, part of the superiority of the best performing varieties can be traced to nongenetic causes, such as favorable field position or chance escape from some disease or insect. Thus, if the test were repeated, the mean performance of the originally superior varieties would revert partially toward the population mean.

In replicated tests, such as the one upon which Table 2 is based, it is possible to estimate the performance of the varieties in subsequent tests. These values are listed under mean purity (genetic) in Table 2. For example, the purest 10% of the varieties would be expected, in subsequent tests, to have a mean purity of 87.1%, compared to 83.6% for the unselected population. Since approximately 10% of the Stage III varieties are advanced to Stage IV in the Canal Point program, purity would be increased only about 3.5% if high purity were made the sole criterion of selection. Practically, this is a rather limited response to such strong selection pressure, and it appears that purity is not a very important selection criterion in Stage III.

Since purity values are rather uniform among Canal Point test varieties, brix values provide an acceptable estimate of sugar yield per ton of cane. Using brix values as estimates of juice quality in early stages of the breeding program would eliminate the need for making polarimeter readings to estimate sucrose percentage and would facilitate juice analysis in early tests.

Another factor which justifies omission of polarimeter measurements in early variety selection stages is the positive correlation between brix and purity (Table 3). Averages over three years, the correlation was .68 in Stage II and .75 in Stage III. Since high brix will continue to be an important selection criterion, increased purity will be achieved automatically because of its association with high brix percent.

Table 3. Correlations* between brix, sucrose and purity.

Test	Brix and purity	Sucrose and purity	Brix and sucrose
Stage II	.68	.87	.93
Stage III	.75	.91	.95
Stage IV	.43	.75	.91

*Means for 3 years. All values significantly greater than zero at the 1% level.

Even though the direct benefits of selecting for high purity are small, one should examine the indirect effects before concluding that purity is not an important selection criterion in early selection stages. Table 4 shows how selection for high or low purity would affect stalk number, stalk weight, brix, and sugar yield of selected clones in a Stage III test. High-purity clones have higher brix and sugar yields than low-purity clones. There is also an indication that high-purity clones might have lower stalk number and stalk weight, though here the data are not conclusive. On the surface it would appear that disregarding purity would lead to losses in brix and sugar yield. However, since brix will continue as a selection criterion, these losses can be prevented.

Table 4. Characteristics of high and low-purity entries in 1972 Stage III test.

	Stalks/ m ²	Stalk weight (kg)	% Brix	Metric tons sugar/ha
Highest - 20% purity	8.15	1.40	18.1*	12.41*
Lowest - 20% purity	8.49	1.48	16.4*	10.92*
LSD .05	0.81	0.14	0.44	0.94

*Significantly different at 5% level of probability.

Table 5 lists mean purities of all test varieties in Stages II, III and IV for several years. Comparisons among rows in Table 5 suggest that the clones entering our tests today have no higher purity than those of several years ago. Apparently the parent clones currently being used to generate our seedling populations are not superior in purity to those used during the previous 4 or 5 years.

Table 5. Mean* purity of varieties in Stage II, III, and IV tests.

Year grown	Stage II	Stage III	Stage IV
1969	79.5	----	----
1970	78.3	78.3	----
1971	83.3	77.7	----
1972	----	77.2	83.3
1973	----	----	86.1
1974	----	----	84.2

*Annual means are based on approximately 300 clones in Stage II, 80 clones in Stage III, and 12 clones in Stage IV.

A second observation possible from Table 5 is that Stage IV varieties are significantly higher in purity than clones in Stages II and III. This probably reflects the effects of selection for high brix, though it may also arise in part from differences in the way Stage IV tests are grown and sampled.

De-emphasizing the use of purity determinations in Stages II and III at Canal Point does not discount the importance of purity. We will continue to obtain purities for Stage III samples from at least one of the four test locations, to eliminate clones with unacceptably low purity. Purity determinations will continue in Stage IV tests, and purities will be determined for all clones used in the crossing program. Purity measurements might also be desirable in early selection stages following crosses where one or both parents had low purity. Such a situation might arise in crosses of sucrose canes with syrup canes or with Saccharum spontaneum L.

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SELECTION FOR COLD TOLERANCE IN SUGARCANE
SEEDLINGS FROM NEW GERMPLASM

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ABSTRACT

Over 40,000 seedlings from 35 bi-parental crosses involving cold tolerant parents were planted in peat pots. When actively growing, the young seedlings were frozen at 22°F for 8 hours. Control seedlings of each cross were kept unfrozen. Seedlings killed by freezing (approximately 85-90%) were discarded. The selected progenies were planted in the field in paired comparisons with the unfrozen unselected progenies from the same cross. On Jan. 14, 1975, a 23°F freeze occurred in the field. Variation in leaf cold tolerance among the 35 crosses was apparent soon after the freeze. However, resistant seedlings from the frozen selected progenies were no more frequent than seedlings from unselected progenies. Progenies of 4 crosses were split and rated for stalk cold tolerance, but again, progenies frozen and selected as seedlings were not superior to the unselected progenies. The frequency of cold tolerant clones could be increased by careful parent selection, but not by freezing young seedlings and selecting survivors.

INTRODUCTION

The resistance of young sugarcane plants to mild natural freezes varies among clones (1). Irvine (4) described a technique that separated hybrid clones on the basis of freeze resistance. When he applied the technique to young sugarcane seedlings in metal or wood flats, the results indicated that the damage often was confined to the perimeter of the flat, that there were no apparent differences among crosses and that the seedlings were more resistant to freezing than had been expected.

Freezing older potted seedlings (2 each in 2 1/4 inch peat pots) about 18 inches tall from soil level to leaf tip gave more uniform results. The seedlings reacted to freezing like young sugarcane clones and there often appeared to be differences among the progenies of the different crosses. An experiment was conducted to determine the effectiveness of this technique in screening sugarcane clones for mature plant leaf or stalk cold tolerance. The results are presented in this paper.

MATERIALS AND METHODS

Over 40,000 seedlings from 35 crosses of the 1973 Houma basic series were experimentally exposed to freezing temperatures in March and early April, 1974. When the seedlings were about 18 inches tall, they were placed in night temperatures in the upper 40's F to mid 50's F for one or two nights. The seedlings were then exposed to 22°F for an 8 hr period. Frozen seedlings were detected and discarded soon after thawing.

In mid-April, the surviving progeny of the 35 crosses, approximately 6000 seedlings, were transplanted to the field. The experimentally frozen and selected progenies (50 to 400 seedlings per cross) were planted on an adjacent row to the unfrozen, unselected progeny of the same cross. Single stolls of CP 65-357 were interspersed in the planting or nursery as a control.

The seedlings grew until the first freeze on December 3, when a low temperature of 27°F was recorded. Freeze damage was apparent in the nursery 4 days later and the frozen and unfrozen progenies were rated for leaf tolerance. Freeze damage was too light (over half the seedlings still had live terminal buds) for final selection.

On January 4, 1975, a second freeze occurred (23°F at 3 ft height). Freeze damage was very severe. Four days later we examined and selected the entire nursery.

We made a detailed study of the progeny of 4 crosses that showed variation in leaf tolerance to cold. Parentage and percentage of seedlings discarded after freezing were as follows: Cross

Research at this location is done in cooperation with the Louisiana Agricultural Experiment Station.

545 (NCo 310 X US 74-9), 86%; Cross 614 (CP 65-357 X US 74-17), 88%; Cross 575 (CP 48-103 X US 74-17), 89%; and Cross 566 (CP 61-39 X US 72-69), 78%. Three of the 4 progenies were BC₂ progenies of *Saccharum spontaneum*, clone US 56-15-8, and one was a BC₁ progeny of *S. spontaneum*, clone SES-6.

We examined 50 seedlings in the frozen selected progenies and 50 seedlings in the unselected progenies of the 4 crosses and rated each for leaf and stalk tolerance to cold.

Leaf tolerance to cold was rated on a scale from 0, no frozen leaf tissue, to 9, 100% of leaf tissue frozen and dead.

Stalk tolerance to cold was rated on 2 stalks of each seedling, split lengthwise from top to bottom. Each seedling was assigned to a class from 0 to 4. The classes were rated as 0 - damage to terminal bud only, 1 - terminal bud and 25% of stalk length frozen, 2 - terminal bud and 50% of stalk length frozen, 3 - terminal bud and 75% of stalk length frozen, 4 - terminal bud and entire stalk frozen.

An analysis of variance was calculated to evaluate differences among progenies of crosses and among the experimentally frozen selected and experimentally not frozen, and unselected progenies for leaf and stalk tolerance to cold. The χ^2 test was also applied to determine the significance of deviations from expected frequencies of leaf and stalk cold tolerance in the experimentally frozen selected progenies from those of the unselected progenies.

RESULTS AND DISCUSSION

There were differences among the 35 progenies in leaf tolerance to cold following the December 3 freeze. In some crosses, most of the seedlings still had a large green band of leaf and over 50% of the terminal buds survived. In other crosses, in most of the seedlings, the leaves were almost entirely damaged and the terminal buds were killed. Despite the striking difference in the response of the progenies of different crosses, comparisons among the 35 pairs of experimentally frozen and unfrozen progenies indicated no apparent differences.

Following the second freeze there was no green leaf tissue in any stool of the control variety CP 65-357. Commercial varieties in an adjacent field also showed little or no green tissue. Most of the seedling progenies were similarly damaged; however, the progeny of a few crosses still appeared more cold tolerant, as a whole, and individual seedlings exhibited varying amounts of green leaf tissue--even in crosses generally not tolerant to cold.

The analysis of variance for leaf and stalk tolerance to cold for the progenies of the 4 crosses studied in detail is given in Table 1. There were significant differences in leaf tolerance to cold among the 4 progenies. Cross 545 (NCo 310 X US 74-9) significantly more cold tolerant than the other 3 crosses (Table 2).

Table 1. Analysis of variance for leaf and stalk tolerance to cold in progenies of 4 crosses.

	:	:	Leaf		:	Stalk				
Sources of variation	:	D.f.	:	M.S.	:	F.	:	M.S.	:	F
Crosses	:	3	:	4.56	:	49.03**	:	1.05	:	5.25
Frozen vs. Unfrozen	:	1	:	0.40	:	4.30	:	0.05	:	0.25
Error	:	3	:	0.09	:		:	0.20	:	

**Significant at 1% level of P.

The analysis of variance showed no significant difference in leaf tolerance to cold between means of progenies experimentally frozen and selected and unselected progenies (Table 1). However, the frequency distributions of the selected and unselected progenies were close to being identical only for cross 575. In the other 3 crosses the frequency of clones less tolerant to cold was actually significantly greater (χ^2) in the experimentally frozen selected progenies.

There were no significant differences in stalk tolerance to cold among the 4 crosses studied. In the case of CP 65-357, variability was high; stalks of the control ranged from 50 to 100% frozen (classes 2 to 4). There were no live terminal buds in any of the seedlings examined, but 12

seedlings in cross 545 (NCo 310 X US 74-9) and 5 seedlings in cross 575 (CP 48-103 X US 74-17) had no visible stalk damage (Table 3). These seedlings might have survived a slightly less severe freeze.

Table 2. The frequency distribution of seedlings for leaf tolerance to cold (0-9) of 4 sugarcane progenies experimentally frozen and selected (F) or not frozen experimentally and unselected (U).

selected (U).																								
Cross	:	Tolerance to cold												:	:									
no.	:	0	:	1	:	2	:	3	:	4	:	5	:	6	:	7	:	:	:	Av.	:	χ^2		
545 (F)	:	:	:	2	:	5	:	3	:	5	:	8	:	11	:	7	:	6	:	3	:	5.4	:	15.68**
545 (U)	:	:	:	1	:	6	:	7	:	9	:	18	:	3	:	2	:	1	:	3	:	4.5	:	
566 (F)	:	:	:	:	:	:	:	:	:	:	:	2	:	4	:	15	:	3	:	26	:	7.9	:	14.40**
566 (U)	:	:	:	:	:	:	:	:	:	1	:	13	:	3	:	4	:	1	:	28	:	7.5	:	
575 (F)	:	:	:	:	:	:	:	:	:	3	:	2	:	3	:	5	:	9	:	28	:	8.0	:	3.38
575 (U)	:	:	:	:	:	:	:	:	:	:	:	5	:	3	:	7	:	2	:	33	:	8.1	:	
614 (F)	:	:	:	:	:	:	:	:	:	:	:	3	:	2	:	5	:	2	:	38	:	8.4	:	10.31*
614 (U)	:	:	:	:	:	:	:	:	:	:	:	3	:	6	:	11	:	8	:	22	:	7.8	:	
CP 65-357	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	8	:	9.0	:	

* Significantly different at the 5% level of P.

**Significantly different at the 1% level of P.

Table 3. The frequency distribution of seedlings for stalk tolerance to cold (0-4) of 4 sugarcane progenies experimentally frozen and selected (F) or not frozen experimentally and unselected (U).

unselected (U).														
Cross	:	Stalk tolerance to cold										:		
no.	:	0	:	1	:	2	:	3	:	4	:	Av.	:	χ^2
545 (F)	:	5	:	14	:	14	:	7	:	10	:	2.0	:	6.14
545 (U)	:	7	:	23	:	13	:	4	:	3	:	1.5	:	
575 (F)	:	4	:	15	:	14	:	7	:	10	:	2.1	:	14.32**
575 (U)	:	1	:	4	:	11	:	16	:	18	:	2.9	:	
614 (F)	:		:	8	:	16	:	16	:	10	:	2.6	:	9.52*
614 (U)	:		:	14	:	24	:	5	:	7	:	2.1	:	
566 (F)	:		:	2	:	0	:	11	:	37	:	3.7	:	7.52
566 (U)	:		:	3	:	4	:	19	:	24	:	3.3	:	
CP 65-357	:		:		:	1	:	2	:	5	:	3.5	:	

* Significantly different at the 5% level of P.

**Significantly different at the 1% level of P.

Again, the analysis of variance showed no significant differences between means of progenies experimentally frozen and selected and unselected progenies (Table 1). χ^2 was not significant for 2 of the 4 progenies and the frequency of cold tolerant clones was greater than expected in the selected progeny of cross 614 and fewer than anticipated in the selected progeny of cross 575 (Table 3).

Because our results showed that nothing could be gained and something could be lost in selection of mature plant leaf or stalk cold tolerance by experimentally freezing young sugarcane seedlings, this technique has been abandoned in our selection program.

Dunkelman and Breaux (3) reported a high level of cold tolerance in parent clones of S. spontaneum. It is very encouraging that BC₁ and BC₂ progenies from some of these also retain cold tolerance. Sixty-two clones with superior cold tolerance were selected from these progenies. It is not known if their level of tolerance is equal to that of the S. spontaneum clones as tolerance level comparisons must await more precise testing.

Brandes (2) crossed S. spontaneum X S. officinarum and obtained cold tolerant progeny for 3 generations. However, repeated backcrossing to S. officinarum (nobilization) resulted in the loss of cold tolerance.

Roach (6) demonstrated the dosage effect from additional S. officinarum chromosomes for other commercially important characteristics and suggested (7) that these effects reduced the probability of obtaining the extreme levels of cold tolerance of S. spontaneum at BC₁ and higher levels of nobilization.

The recent introduction of new germplasm (3) has increased the frequency and quality of cold tolerance (5). The data presented here demonstrate the heritability of this cold tolerance. The performance of cross 545 (NCo 310 X US 74-9) suggests that dosage effects of S. officinarum chromosomes are minimized by the use of the most cold tolerant interspecific hybrids (NCo 310) as recurrent parents. Intercrossing of cold tolerant BC₂ or BC₃ selections might be needed to intensify cold tolerance before proceeding with the backcrossing program.

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PAPERS PRESENTED AT 1975 MEETING OF FLORIDA DIVISION

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PROGRESS REPORT ON CHARACTERISTICS OF SUGARCANE VARIETIES
THAT AFFECT HARVESTER PERFORMANCE EFFICIENCY

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ABSTRACT

To determine the most desirable characteristics of sugarcane varieties for mechanical harvesting, we established an experiment in which nine varieties were used, and we harvested the cane with a one-row, gathering-type harvester. The varieties were selected with a range of stalk sizes and growth characteristics. The cane was harvested in November 1974, about 13 months after planting. Two additional harvests are planned for which similar mechanical harvesting equipment will be used. The experimental design was a randomized block design with three replications. Each test plot was four rows wide and 300 feet long, with adequate turning room for positioning equipment between replications. Data were taken on the center two rows of each test plot. Harvester and transport traffic were kept uniform over the field so mechanical damage could be evaluated in the ratoon crops. Plant population counts were made in August and October, and brittleness tests were made in October. Plots were rated for erectness before and after preharvest burning. (The position of the varieties at harvest ranged from erect to recumbent.)

All varieties were harvested without excessive uprooting. Yields ranged from 44 to 60 tons per acre. The most recumbent variety, C1 54-378, had the lowest harvester performance efficiency (93.8%). The erect varieties had performance efficiencies of about 98%. C1 41-223 had the highest trash content (11.13%); that of other varieties ranged from 5.0 to 10.39%. High trash content was associated with recumbency and nonuniform growth, both factors tending to prevent efficient mechanical topping. CP 68-1067 had the highest yield (59.8 tons per acre) and was the most erect variety after burning.

INTRODUCTION

For maximum harvester performance efficiency and low trash content, a uniform stand of erect sugarcane stalks is necessary. Erect, uniform stalks allow good topping by mechanical harvesters. Plant cane fields generally harvest better with mechanical harvesters than do ratoon fields because the root system is firm and the row of cane is continuous. Harvesters can gather and lift the stalks erect if the root system holds the stalk firmly. However, the soft muck soils in Florida do not provide adequate anchorage for the support of stalks in high-yielding fields.

Two distinct types of harvesters that are manufactured by seven companies are used in Florida. The gathering-type harvester erects the cane by bringing the stalks from a row into a narrow space between two row dividers. It has no provision for cutting matted cane from the next row if it cannot be lifted erect. The recumbent-type harvester does not erect or move the cane but merely cuts through the tangled material as it is presented to the machine and lifts it onto a conveyor. The recumbent-type harvester leaves short pieces of cane as the swath is separated, and the pickup mechanism must be wide enough to pick up these pieces on a subsequent pass through the field. The degree to which various varietal characteristics affect harvesting efficiency depends on whether a gathering or recumbent-type harvester is used.

We conducted this experiment to determine which varietal characteristics are most important in determining the efficiency of gathering-type harvesters. In additional experiments, cane will be planted for harvesting by a recumbent-type harvester. The results presented are from the first year of the experiment and reflect the harvestability of plant cane with a gathering-type harvester.

MATERIALS AND METHODS

Two continuous lines of nine varieties of sugarcane (C1 41-223, C1 54-378, CP 56-59, CP 63-306, CP 63-588, CP 65-357, CP 66-1079, CP 68-1067, and L 61-49) were planted on October 24-25, 1973. We selected varieties with diverse stalk and growth characteristics from commercial and

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unreleased varieties to determine their effects on harvester efficiency. We kept harvester and transport traffic uniform through the field so we can determine the effect of field traffic on subsequent ratoon crops.

The experimental design was a randomized complete block with three replications. Each test plot consisted of four rows that were 300 feet long. The overall test area was bordered with CP 63-588. Space was left between replications to allow turning of the harvester and transport wagons.

Plant counts were made on 30 feet of each of the center rows on August 13 and October 11, 1974. Brittleness ratings were determined from deflection measurements made on October 11, 1974, with the brittleness tester developed in Louisiana (1). The two center rows of each plot were used for determining cane yield per acre, average stalk diameter, total length of skips in the row that were over 3 feet long, harvester performance efficiency, trash content, and sugar content. Sugar contents were determined from analysis of the juice samples at Canal Point, and the appropriate Variety Correction Factors were applied (2).

Erectness ratings were made independently by four researchers before and after the cane was burned on November 24, 1974. A scale of 1 (erect) to 10 (totally recumbent) was used. A rating of 5 indicated that the stalks were leaning at a 45° angle.

Plots were harvested with a Massey-Ferguson 201 harvester on November 25, 26, 27 and 29, beginning about 18 hours after burning. Immediately before harvest, all skips 3 feet or longer were measured. The diameters of 20 stalks were measured in each test plot. As the cane was harvested, samples were taken from the harvester discharge conveyor for trash determination and sugar analysis. The samples for sugar analysis were milled at Canal Point on November 27. Juice samples were collected and analyzed using the simplified Winter Carp Geerlings formula to determine the sugar per ton values.

RESULTS

The plant populations per acre and the brittleness ratings of the varieties are shown in Table 1. Plant counts decreased in most varieties between August and October. The variety with the highest plant population was CP 65-357 with an average of 33,800 plants per acre. The brittleness ratings varied from 6.6 for variety CP 66-1079 to 10.4 for Cl 41-223. CP 65-357 and CL 41-223, with brittleness ratings of 9.0 and 10.4, respectively, were more difficult to break.

Table 1. Summary of plant populations and brittleness ratings of nine sugarcane varieties, Belle Glade, Florida.

Variety	8-8-74	10-11-74	Avg.	Brittleness ^{1/} rating
CP 65-357	35,400	32,200	33,800	9.0
CP 56-59	28,500	17,000	22,700	8.1
CP 63-588	28,200	21,700	24,900	8.1
CP 63-306	31,400	26,100	28,700	8.2
CP 66-1079	29,000	26,400	27,700	6.6
L 61-49	24,100	25,600	24,800	8.2
CP 68-1067	22,100	22,900	22,500	7.4
Cl 41-223	24,100	20,500	22,300	10.4
Cl 54-378	28,500	18,000	23,200	7.3

^{1/}Average number of 1/8-inch increments of deflection before stalk broke.

Erectness ratings for the varieties ranged from 3.0 to 9.3 before burning and from 4.3 to 9.6 after burning, as shown in Table 2. Some varieties fell noticeably during burning, perhaps due to the removal of trash that supported the stalks or to relaxation of the supporting fibers as a result of the heat. Variety Cl 41-223 had a rating of 4.8 before burning and 5.0 after burning, showing that it did not fall after burning. However, variety CP 65-357, which was rather erect (3.0) before burning, fell (5.7) after burning. Variety Cl 54-378 was almost totally recumbent. Varieties CP 63-588 and CP 63-306 were the next most recumbent varieties. This experiment was planted on relatively soft muck soil and had a higher degree of recumbency than did the general Florida growing area. We did not observe any damage to the stubble due to the passage of the harvester and transport over each row. With the hand-cut harvest system, the loader and transport travel once for each four-row windrow.

Table 2. Summary of erectness ratings, stalk diameters, and total skips of nine sugarcane varieties, Belle Glade, Florida.

Variety	Erectness rating ^{1/}		Stalk diameter ^{2/} (mm)	Skips ^{3/} (Ft)
	Unburned	Burned		
CP 68-1067	3.3	4.3	33.35	183.5
CP 56-59	4.4	5.2	27.56	180.3
Cl 41-223	4.8	5.0	31.34	87.2
CP 66-1079	3.4	6.2	28.22	100.2
CP 63-306	6.0	7.9	26.25	54.8
CL 54-378	9.3	9.6	30.02	113.7
L 61-49	4.0	4.9	26.35	181.3
CP 65-357	3.0	5.7	24.26	149.6
CP 63-588	7.4	7.9	29.06	78.4

^{1/}At a rating of 1, stalk was erect; at 5, it leaned at a 45° angle; and at 10, it was recumbent.

^{2/}Average diameter of 20 stalks measured in each test plot.

^{3/}Average total of skips over 3 ft long in 600 ft of test row.

Plant counts of the nine varieties varied from about 22,000 plants per acre to almost 34,000 plants per acre. The general range was in the 22,000 to 25,000 plants per acre. The average skip data are shown in Table 2 for the two center rows in each 300-foot plot. Varieties CP 63-306, CP 63-588 and Cl 41-223 had very few skips. The average diameters of the stalks are shown in Table 2. Variety CP 68-1067 had the largest diameter of any variety in the test. Stands were poor in some varieties, apparently because of poor germination. Insufficient covering and delays between harvesting and covering may have caused part of the poor germination. The skips did not lower yields in this plant cane crop noticeably. Interestingly, the highest yielding variety, CP 68-1067, also had the most skips. However, the skips allowed weed growth that was difficult to control.

Trash and sugar contents were highly variable due to problems in taking representative samples. Table 3 shows yield, harvester performance efficiency, trash content, sugar content, and sugar yield from these varieties.

Table 3. Average of yield, harvester performance efficiency, trash content, sugar content, and sugar yield of nine sugarcane varieties, Belle Glade, Florida.

Variety	Yield (ton/A)	Harvester efficiency (%)	Trash content (%)	Sugar content (lb/ton)	Sugar yield (lb/A)
Cl 41-223	56.7	97.7	11.13	152.3	8,635
CP 63-588	55.6	97.9	7.79	178.2	9,908
Cl 54-378	44.4	93.8	10.39	200.5	8,902
CP 65-357	53.9	98.1	8.05	152.7	8,230
CP 56-59	47.6	98.3	9.34	172.9	8,230
L 61-49	47.1	98.4	4.99	183.0	8,620
CP 68-1067	59.8	96.8	5.59	193.0	11,541
CP 66-1079	54.7	97.3	7.52	163.5	8,943
CP 63-306	54.3	97.9	8.65	202.1	10,974

Harvester efficiency for the recumbent variety Cl 54-378 was 93.8% and for the erect variety CP 68-1067, 96.8%. Five other varieties harvested at efficiencies close to 98%. Variety L 61-49 showed the highest harvest efficiency with 98.4% of the sugarcane recovered. Variety Cl 41-223 had the highest trash content (11.13%), and the almost totally recumbent variety, Cl 54-378, had the next highest, 10.39%. Variety L 61-49 had the lowest trash content, about 5%. Cane yields ranged from 44.4 tons per acre for Cl 54-378 to 59.8 tons per acre for CP 68-1067. Six varieties had yields between 54 and 60 tons per acre.

The sugar yield data from this experiment were highly variable and were not considered reliable because of the delay between cutting and milling. By the time of milling, the samples harvested early in the experiment apparently had deteriorated, thus losing sugar. Seven mill samples were cut by hand due to wet weather. Varying amounts of tops in mill samples may also have affected sugar yield estimates due to unrepresentative samples.

DISCUSSION

The varieties harvested better than expected in view of the amount of recumbency. Apparently, the cane had a good root system that held the plants in the ground as the harvester gathered and pulled the cane into the harvester. The extreme recumbency of variety C1 54-378 prevented topping and contributed to its high trash content (10.39%). However, the 11.13% trash in C1 41-223 was not expected and was apparently due to stalk nonuniformity, which prevented effective topping.

Although the total amount of skips greater than 3 feet in CP 56-59, L 61-49, and CP 68-1067 was high, the extent of skips seemed unrelated to yield or harvester efficiency. Stalk diameters likewise seemed unrelated to harvester efficiency.

This experiment will be repeated and the test plots harvested for the next two ratoon crops, and wider differences are expected in the harvester efficiency due to wider stubble and a shallow root system. No evaluations of damage to the stubble have been made thus far, but observations during the first year of this experiment indicated only minor stubble disturbance for most varieties. Damage to some varieties is expected in the second and third harvest and will be evaluated. In addition, the nine characteristics measured in this experiment will also be measured in the subsequent tests. Information from these studies should be helpful to plant breeders who are attempting to develop varieties adapted to mechanical harvesting.

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EFFECTS OF DELAY IN COVERING AND OF SEED-PIECE
LENGTH ON GERMINATION OF SPRING-PLANTED SUGARCANE

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ABSTRACT

An experiment was designed to determine the best of 4 seed-piece lengths and 4 times of covering of sugarcane. Plots were planted in February 1975 with seed cane about 15 months old. Germination increased significantly with each increase in seed-piece length from shortest to longest (12.5-17.5 cm, 25.5-30.5 cm, 40.5-45.5 cm, 53.5-58.5 cm). The covering times were 1, 3, 7, and 11 days after the seed cane was placed into open furrows. Germination decreased with each covering delay. Delays in shoot emergence exceeded the rate of delays in covering. For the longest seed-piece length, the 3 day covering treatment caused a 9-15 day delay in the rate of emergence and the 7 day covering treatment caused a 19 day delay in the rate of emergence. In this test, seed cane covered immediately after planting had the best germination.

INTRODUCTION

Mechanical planting of sugarcane must produce good stands with normal planting rates to be accepted by sugarcane growers. Mechanical planters typically apply 2.5-5 t/ha more seed material than conventional hand-planting operations (4). The total mechanization of planting requires mechanical harvesting of seed cane.

Different methods have been recommended (2, 5, 7, 8, 9) for obtaining good germination in different sugarcane production areas of the world. Clements (1) showed that temperature, moisture, and aeration of soil affected germination. Soil temperatures below 70 F severely reduced germination of one variety. Age and length of seed-pieces, positioning of the buds, and different stimulation treatments also affected germination. Findings have been similar (6, 7, 9, 10) with 3-node seed-pieces which are generally used for planting in most sugarcane-producing areas of the world.

Successful mechanical planting would require refinements to eliminate seed damage caused by mechanical harvesters and planters now used in Florida. Normal planting rates produced good stands in Australia, when seed cane was harvested with a MF 201 chopper harvester and treated with a mercurial fungicide before planting (11).

Sugarcane growers can control the length of seed-piece and covering time, but growers do not agree about the effects of these factors on production. Our objective was to determine the best seed-piece length that can be cut with a chopper harvester and the optimum time of covering to produce a good stand of cane under spring-planting conditions.

MATERIALS AND METHODS

We planted CP 63-588, the leading commercial sugarcane variety in Florida (personal communications, E. R. Rice, research agronomist, USDA, ARS, Canal Point, FL). Seed cane about 15 months old, was cut with a Massey Ferguson 201 chopper harvester. The seed material was sorted into 3 seed-piece lengths (25.5-30.5 cm, 40.5-45.5 cm, and 53.5-58.5 cm). For the fourth length (12.5-17.5 cm) 25.5-30.5 cm seed-pieces were cut into halves. On the day after harvesting, seed cane was placed by hand into open furrows at a planting rate of two continuous lines of cane.

The experimental design was a split-plot with 4 replications. Main plots (single rows 36.6 m long) were covering treatments; seed-cane was covered 1, 3, 7, 13 and 24 days after planting. The 13 and 24 day treatments were eliminated on day 11 when heavy rain covered the remaining treatments with soil. Subplots (7.6 m long) were seed-piece lengths. The day 1 covering treatment represents seed cane that was cut one day, placed in open furrows on the next day, and covered immediately. About 130 liters of water were applied to each subplot at the time of covering to insure that moisture was adequate for germination.

In this paper, primary shoot counts represent germination of individual buds. Shoots were counted at regular intervals from the appearance of the first shoot until new shoots stopped appearing. The stand in each subplot was rated for production potential by a commercial farm manager on the scale: 1 = very poor, 2 = poor, 3 = fair, 4 = good, and 5 = excellent. Data were statistically analyzed with techniques in Steel and Torrie (11).

RESULTS AND DISCUSSION

Primary shoot counts 73 days after seed was placed in the furrows appear in Table 1. When counts were averaged over covering treatments, each increase in seed-piece length produced a significantly higher shoot count. The longest seed-piece length, 53.5-58.5 cm, produced 22 and 47% more shoots, respectively, than the 40.5-45.5 and 25.5-30.5 cm seed-piece lengths. Average shoot count in the best seed-piece length and covering time combination produced only 26.5 shoots per subplot from approximately 125 buds or about 21% germination.

Table 1. Average number of primary shoots from 4 lengths of seed cane and 4 covering times 73 days after seed-pieces were placed in open furrows.

Covering day	Seed-piece lengths (cm)				Avg. for covering day
	12.5-17.5	25.5-30.5	40.5-45.5	53.5-58.5	
1	8.50	14.25	22.25	26.50	17.94a
3	3.50	11.75	17.25	22.75	13.81 b
7	0.25	5.50	8.00	11.50	6.31 c
11	1.12	4.25	6.62	9.00	5.38 c
Avg. for lengths	2.90D	8.20C	12.20B	15.75A	

Means within a column followed by the same lowercase letter and means within a row at each counting date followed by the same uppercase letter are not significantly different (5% level) according to Duncan's multiple range test.

The difference between day 1 and day 3 covering treatments was 4.13 shoots per subplot when averaged over the different lengths (Table 1). Among covering treatments, the 1 and 3 days produced significantly more shoots than the 7 and 11 days. Shoot count of the 7 day covering treatment averaged only 35% of that for 1 day. In spring planting, seed-pieces apparently should be covered immediately for best germination. Broadhead (1) reported that cane yields were significantly reduced by delays in covering of 14 and 21 days but not of 7 days. However, Coleman (3) found that the percent germination of whole stalks actually increased when stored up to 20 days before planting.

The response curves for the seed-piece lengths (Fig. 1) show that the 3 day covering treatment caused a 9 to 15 day delay in the rate of shoot emergence. With the longest seed-pieces, the 7 day covering treatment caused a 19 day delay in the rate of shoot emergence. Germination in the shorter lengths was too low for a reasonable comparison of the number of days that germination was retarded. As the interval between placement of seed cane in the furrows and covering increased, exposure to sunlight and drying conditions increased. Exposure to sunlight has been shown to retard germination (8, 10). Exposure to sunlight and loss of water by dehydration of the short seed-pieces might explain the increased delay in the rate of shoot emergence beyond the covering treatment delay.

Broadhead (1) reported that the number of shoots increased as seed-piece length was reduced from 8- to 2-bud segments; but, the shoots from the 2-bud segments were weak and produced significantly lower cane yield than the longer lengths. The stand ratings, for potential cane production, in our experiment (Table 2) were based on plant vigor and tillering in addition to shoot counts.

The stand ratings were low for the seed-piece lengths averaged over all the covering treatments. The stand rating was significantly higher for the 53.5-58.5 cm seed-piece length than those obtained with the other seed-piece lengths, but the two intermediate seed-piece lengths were not different. The stand rating was significantly lower for the 12.5-17.5 cm length than for the other lengths. A mean stand rating, 3.59, was significantly higher for the 1 day than for the other three covering treatments. The 3 day covering treatment produced a significantly higher stand rating than the 7 and 11 day covering treatments, which did not differ significantly. These rankings agreed very closely with the primary shoot counts (Table 1). The 53.5-58.5 cm seed-piece length and 1 day covering treatment combination produced the highest average rating, 4.6, showing a good stand of sugarcane.

Our results indicate that mechanical planters should be designed for the longer seed-piece lengths tested and that seed cane should be covered immediately after placement in furrows. If seed material about 55 cm long is covered immediately after placement in the furrow, normal planting rates should produce good stands even under spring-planting conditions.

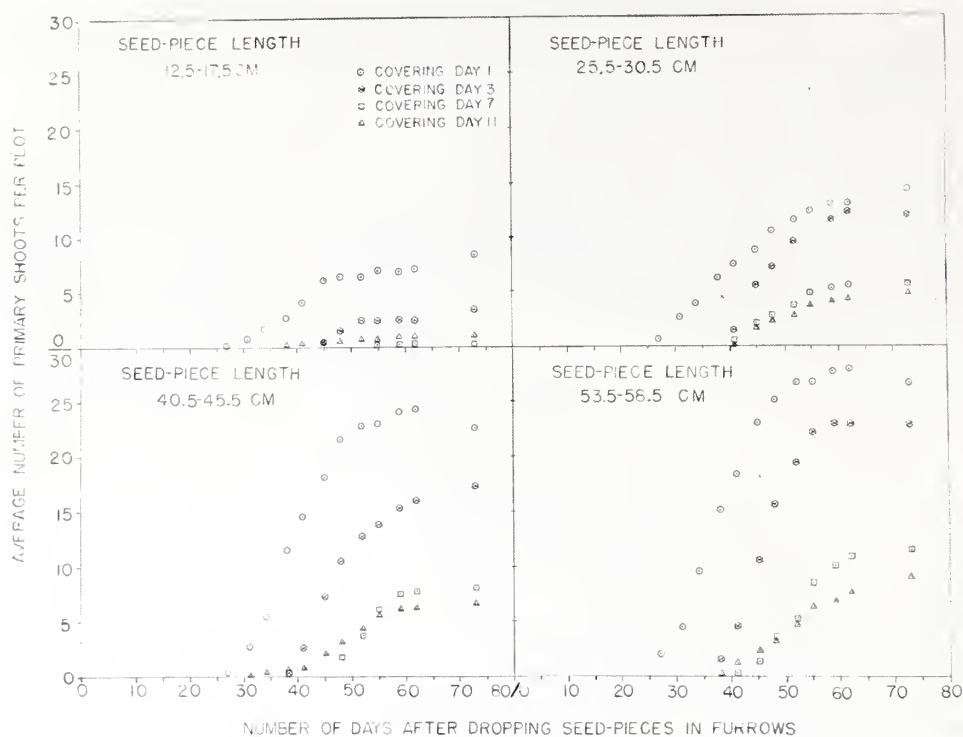


Figure 1. Average number of primary shoots (from 4 lengths of seed cane and 4 covering times) counted between 27 and 73 days after seed-pieces were placed in open furrows.

Table 2. Ratings of sugarcane stands by a commercial farm manager 73 days after seed-pieces were placed in the open furrows.

Covering day	Seed-piece lengths (cm)				Avg. for covering day
	12.5-17.5	25.5-30.5	40.5-45.5	53.5-58.5	
1	2.63	3.00	4.12	4.62	3.59a
3	1.50	2.88	3.12	3.75	2.81 b
7	1.25	2.00	1.50	2.12	1.72 c
11	1.38	2.00	2.19	2.25	1.96 c
Avg. for lengths	1.63C	2.38B	2.63B	3.00A	

1 = very poor stand, 2 = poor stand, 3 = fair stand, 4 = good stand, 5 = excellent stand.

Means within a column followed by the same lowercase letter and means within a row followed by the same uppercase letter are not significantly different (5% level) according to Duncan's multiple range test.

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QUALITY OF BAGASSE AS A FUEL - PRELIMINARY OBSERVATIONS¹

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INTRODUCTION

0.99 MCF/ton cane 1973 average gas consumption for wholly bagasse burning factories. 9,140,000 MCF total industry gas consumption small by comparison with other industries.

However, cost of gas and substitute fuels and limited availability of gas require a marked reduction in supplementary fuel requirements.

0.99 MCF/ton of cane about 30% of total furnace energy input. Available fuel value in bagasse should be adequate for factory needs with minimum supplementary fuel.

Achieving fuel self sufficiency is not an easy proposition and involves the areas of 1) quality of bagasse as a fuel, 2) efficiency of conversion of the fuel to energy, and 3) efficiency of utilization of the energy in the factory.

CANE AND BAGASSE QUALITY RELATED TO FUEL VALUE

Fiber in Cane. Important as a factor in chemical control and in the design of factory energy systems. Without bagasse measuring systems, magnitude of figure is a guess. 1974 crop run fiber content as reported by 14 factories.

Minimum	12.95% cane
Maximum	18.78% cane
Average	16.83% cane

Audubon Sugar Factory data for hand cut and cleaned 100 lb samples (Farrel mill) and machine cut 2 to 3 ton lots of cane (Squire milling tandem):

		<u>Hand cut</u>		<u>Machine cut</u>
		<u>1973</u>	<u>1974</u>	<u>1974</u>
Number of runs		8	5	18
Trash % cane		---	---	3 to 30%
Fiber % cane:	Minimum	10.62	10.63	11.58 - 12.34
	Maximum	12.26	13.91	16.00 - 17.90
	Average	11.51	12.04	14.45

Most of the machine cut cane was burned--the degree depending on the weather. A few runs were not. 17.90% fiber was from the 30% trash run.

Bagasse Fuel Value. Hugot: Higher heating value (HHV) 8280 btu/lb dry basis
Lower heating value (LHV) 7650 btu/lb dry basis

Based on reported calorimeter data with natural ash in bagasse.
Assuming 50% moisture, heating values about 1/2 of above on wet basis.

Meade: HHV 8350 btu/lb ash free dry bagasse. Lends itself to correction to any ash value.

Bagasse Moisture. 1% moisture represents an equivalent loss in heating value and 0.6% in calculated furnace efficiency.

¹Editors Note: Dr. Seip was in the process of preparing a finished manuscript of this paper when he became ill and was unable to complete it. Because of the importance of the research, I have taken the liberty of publishing the paper in this unfinished form.

Louisiana: 1937 through 1941 average 48.26
1969 through 1973 average 52.09
1974 crop averages ranged from about 50.60 to 55.00.

Bagasse Ash. Hand cut cane: Paturau - 19 sources (9 cane growing areas).

Minimum: 1.0% on dry matter (Florida)
Maximum: 3.9% on dry matter (Puerto Rico)
Average: 2.05% on dry matter

2.05% dry basis would be about 1.02% a wet basis (50% moisture).

Machine cut cane. Obviously equated with field soil in cane. Magnitude of latter a function of type of soil, rainfall, harvesting practices, and cane washing system. While field soil is increasingly recognized as a major problem in Louisiana, little has been done to quantify this item in the cane, juice, or bagasse. In cane: Hawaii dry cleaning studies involved a technique for field soil in cane. In juice: Routine control inspections in some areas for suspended solids in juice by drying. In bagasse: Limited literature data. Determined as ash in bagasse.

Particle size. Bagasse particle size--a measure of the severity of preparation and extraction. Might reflect unburned foliage or tops. Various methods for determining--generally as a measure of preparation efficiency--as dry sieving and % through specified sieve mesh, compression and density determination, and displacement index (D.I.), which is a measure of the unruptured juice cells.

PROCEDURE

Areas of investigation.

1. Simulation studies: 10% tops, green leaves, and Sharkey and Commerce soil were added to hand cut and cleaned cane. The cane was then milled with 20% maceration water and 4 passes through the Farrel mill.
2. Factory studies: Both weekly composites of bagasse from specified factories and grab samples were analyzed.
3. Bagasse depithing studies: Analyses were run on the whole bagasse and on the fiber (accepts) and pith (rejects). These studies supplemented an investigation to determine the feasibility of depithing at the factory--shipping the fiber and burning the pith in the factory furnaces.
4. Bagasse drying studies: Analyses were run on the whole bagasse from the milling tandem, on the sidestream from natural gas fired driers, and on the blended material to the furnaces.

Analyses.

Particle size distribution: Dried bagasse was fractionated in a Ro-Tap sieve shaker stacked with sieves of the following Tyler Sieve No.: 1/2 in., 4, 6, 12, 28, 90, and the pan.

Ash: Sulphated ash was run on the bagasse as received and on washed samples of the material. The washing entailed repeated agitation in a Waring Blender and flushing through a Moisture Teller sieve. The washing was an attempt to remove field soil in the bagasse and obtain a sample containing only the natural ash. The difference in ash reflected the field soil in the bagasse.

In the results section, only the ash of the as received samples is reported for simplicity.

Heating Value: Samples of both the as received and washed bagasse were run on the Parr oxygen bomb calorimeter.

All ash and heating value inspections were run in duplicate.

RESULTS

Simulation studies. Table 1 shows the effect of trash on cane and bagasse quality. The Sharkey and Commerce soil analyses were:

<u>Component</u>	<u>Sharkey</u>	<u>Commerce</u>
Organic Matter	17.0	10.5
Ash	77.0	87.4
Moisture	-----2 to 6 -----	

Table 1. Simulation studies: Effect of trash on cane and bagasse quality--Variety CP 65-357.

	Clean cane	10% tops	10% green leaves	10% field soil	
				Sharkey	Commerce
Fiber % cane	11.11	11.52	12.78	16.26	17.17
Moisture % bagasse	52.90	54.20	52.00	48.00	44.00
Ash % dry bagasse	2.58	2.95	3.44	22.29	30.32

Marked increase in fiber with field soil. Higher value for fiber and ash would be expected considering the higher ash in Commerce. Low moisture in bagasse for field soil was unexpected and possibly reflected addition of dry soil.

Table 2 shows the effect of trash on the heating value of bagasse. Higher value for Sharkey soil might be attributable to the greater organic matter in this soil.

Table 2. Simulation studies: Effect of trash on the heating value of bagasse--Variety CP 65-357.

	Heating value (HHV) (btu/lb)				
	Clean cane	10% tops	10% green leaves	10% field soil	
				Sharkey	Commerce
Dry bagasse	7993	8086	7904	6586	5871
Wet bagasse	3765	3703	3794	3425	3264

Factory Studies.

Ash: Table 3 shows the ash by run. Factories A, B, and C sent samples in weekly. Additional data to the end of the crop--and the weekly series for three more factories are being completed. Factories G and H were the subject of special investigations.

Table 3. Factory studies: Ash in bagasse by run.

	Ash % dry bagasse						
From:	10/13	10/20	10/29	11/3	11/10	11/17	11/24
To:	10/19	10/26	11/2	11/9	11/16	11/23	11/30
<u>Factory</u>							
A	----	----	5.82	----	7.92	8.86	9.82
B	6.85	7.37	8.40	11.89	12.90	15.43	14.39
C	----	8.17	9.12	13.06	14.41	17.39	14.50
G	6.52	8.52	----	----	----	----	----
H	----	----	9.12	7.87	15.18	16.07	16.41
Average	6.69	7.44	8.11	10.19	12.84	14.68	13.10

The reported values are considerably above the 2.0 to 3.0% for hand cut cane--and the average of 1.50 for the washed samples. All factories show a general increase in ash. There was not a corresponding weekly increase in rain, and the above trend appears to be due to the inability of the fields to dry out as the weather became cooler.

Factory A: Considerable commerce soil, excellent harvesting discipline, and an excellent washing table. Factory B has fought the dual problems of limiting tandem capacity and mill roll and equipment wear. 24.62 ash % dry matter on a grab sample from a Lafourche area factory two days after the two inch rain. 7.13% ash for a Teche area factory after a week of dry weather early in the crop.

Heating value dry basis: Table 4 shows the data by run. The trend follows closely the ash data. As the ash increases the heating value decreases. Heating value of the washed samples showed relatively small variation among runs. Corrected to the average 1.5% ash in bagasse, an average of 8270 btu/lb compares closely with the literature figure of 8350. The data are shown in Table 5.

Table 4. Factory studies: Heating value of bagasse by run--dry basis.

From:	HHV (btu/lb) (dry basis)						
	10/13	10/20	10/27	11/3	11/10	11/17	11/24
To:	10/19	10/26	11/2	11/9	11/16	11/23	11/30
Factory							
A	----	---8004---		7695	7512	7493	7535
B	7825	7867	7708	7554	7405	7477	7171
C	----	7740	7820	7300	7266	7294	7123
G	7719	7816	----	----	----	----	----
H	----	----	7733	7779	7357	7298	7024
Average	7772	7587	7816	7582	7385	7391	7213

Table 5. Factory studies: Heating value of washed bagasse by run--dry basis.

From:	HHV (btu/lb) (dry basis)						
	10/13	10/20	10/27	11/3	11/10	11/17	11/24
To:	10/19	10/26	11/2	11/9	11/16	11/23	11/30
Factory							
A	----	---8150---		8192	7828	8130	8303
B	8194	8119	8202	8254	8068	8186	8254
C	----	8019	7971	8227	8102	8128	8185
G	8062	8081	----	----	----	----	----
H	----	----	8385	8076	8074	8133	8156
Average	8128	8092	8177	7176	8081	8144	8224

Heating value wet basis: A design basis is usually the wet or moist bagasse exiting from the mill reflecting both ash and moisture. Table 6 summarizes moisture by factory. Interestingly, Factory B with the highest moisture has consistently shown the lowest gas consumption in the state.

Table 6. Factory studies: Moisture in bagasse by factory.

	Moisture % bagasse in factory				
	A	B	C	G	H
Minimum	51.91	52.32	51.06	51.39	51.80
Maximum	53.38	54.48	51.86	52.87	52.27
Average	52.70	53.84	51.37	52.13	52.03

Table 7 shows the heating values on a moist or wet basis. Since moisture by factory showed no general increase as the crop progressed, the decrease in heating value is attributable primarily to the increasing ash. These figures differ markedly from a commonly reported figure of 4,000 btu/lb for hand cut cane.

Table 7. Factory studies: Heating value of bagasse by run--wet basis.

From:	HHV (btu/lb) (dry basis)						
	10/13	10/20	10/27	11/3	11/10	11/17	11/24
To:	10/19	10/26	11/2	11/9	11/16	11/23	11/30
Factory							
A	----	---3731---		3616	3511	3602	3624
B	3570	3581	3557	3471	3401	3457	3419
C	----	3786	3822	3514	3556	3551	3433
G	3752	3683	----	----	----	----	----
H	----	----	3693	3717	3559	3484	3386
Average	3661	3695	3701	3580	3507	3524	3466

The heating value for the high ash Lafourche area factory cited earlier was 3084.

Depithing Studies. Table 8 shows the results of two runs, one for Factory D early in the crop (10/23) and one for Factory E late in the crop (12/5). A marked increase in ash and decrease in heating value is noted for the latter factory. In both cases, the ash in the pith was about double that in the fiber portion. The bagasse ash for D would appear to be low and the heating value high. The washed pith sample for D was an attempt to simulate what might be done to lower the ash in the pith. Commercially, some mechanical method of separation would have to be considered.

Corrected to a bone dry and ash free basis, the heating values for bagasse, fiber, and pith appear to be of the same order of magnitude.

Table 8. Bagasse depithing studies: Ash and heating value.

Moisture as % bagasse Ash as % dry matter Heating value (HHV) as btu/lb	Factory and date					
	D 10/23/74			E 12/5/74		
	Bagasse	Fiber	Pith*	Bagasse	Fiber	Pith
Moisture	54.50	----	-----	55.25	-----	-----
Ash	6.72	6.87	15.29	23.11	18.12	36.57
Heating value, dry	7814	7832	7272	6437	6669	6175
wet	3556	----	-----	2881	-----	-----
*Washed pith: Ash	10.58					
Heating value, dry	7613					

Table 9 shows the sieve fractions. All the pith passed through a No. 6 sieve (0.131 in. mesh), the first fraction being collected on a No. 12 sieve. The high % collected on the pan for Factory E would appear to reflect field soil.

Table 9. Bagasse depithing studies: Sieve fractions.

% through Tyler sieve No.	Factory and date					
	D 10/23/74			E 12/5/74		
	Bagasse	Fiber	Pith	Bagasse	Fiber	Pith
6	45.72	44.44	100.00	54.43	65.69	100.00
90	0.00	0.25	0.39	3.86	2.39	6.43

Bagasse Drying Studies. Table 10 shows the data for one run in which samples were collected from the mill, the sidestream existing from the driers, and the blended material to the furnaces. The lower ash for the dried material would indicate that some of the field soil was removed by way of the cyclone separators serving the driers.

Table 10. Bagasse drying studies: Ash and heating value.

Moisture as % bagasse Ash as % dry matter Heating value (HHV) as btu/lb	Factory and date		
	G		
	12/1/74		
	Mill product	Dried bagasse	Furnace feed
Moisture	53.02	-----	-----
Ash	19.39	10.76	16.21
Heating value, dry	6954	7463	7346
wet	3267	-----	-----

Table 11 summarizes the particle size distribution. The slightly higher percentage of the total through the No. 6 sieve would indicate that there was some bagasse attrition in the tumbling through the driers.

Table 11. Bagasse drying studies: Sieve fractions.

% through Tyler sieve no.	Factory and date		
	G		
	12/1/74		
	Mill product	Dried bagasse	Furnace feed
6	59.48	62.21	59.41
90	0.66	0.50	0.59

A NEW APPROACH TO AUTOMATIC DENSITY CONTROL

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Several years ago we began talking to a few people in some of the factories about the possible use of the Dynatrol density analyzer. We were told by several plant operators and consulting engineers that the raw sugar manufacturing industry was in need of an accurate, reliable, and simple method of continuously measuring, recording, and controlling liquid density.

The differential pressure type was probably the most widely-used continuous-density transmitter. It utilizes a standpipe and two dip tubes, one inserted just below the overflow and the other down to a point near the bottom. A small rotameter and needle valve in a purge line to each tube controls the purge flow rate, and a differential pressure transmitter senses the back pressure in each dip tube and sends a signal to the recorder-controller proportional to the liquid density in the standpipe. The Dynatrol is easily calibrated to a 10 brix range for good sensitivity--say 60 to 70 brix--but to get this range with a differential pressure transmitter having 0 to 20" water range would require a standpipe 27 feet high. So a narrow range, high sensitivity density controller was virtually unknown, and the industry settled for an instrument with a 40 brix range and poor sensitivity.

Other types such as the bouyant float transmitter and the light refractive index transmitter were tried but with limited success. The indicating hydrometer remained the most universal means of measurement, and it can't be read much closer than about ± 1 brix. It requires skilled manpower in constant attendance, and there is no continuous record of the operation--only the handwritten values on the log sheet, which are always subject to question.

One of the reasons the Dynatrol was slow to gain acceptance was the fear of scaling, as had been experienced in the standpipe with the differential pressure type. The difference is that the standpipe holds liquid at very low velocity and usually is open to the atmosphere, whereas the Dynatrol has a high velocity sample at process pressure going through a stainless steel tube.

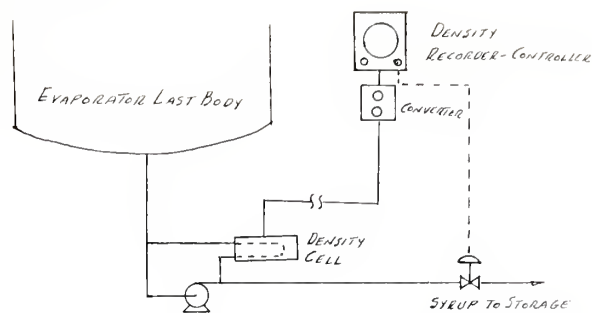
In 1972, we made a trial run on evaporator syrup at Cora, Texas, and on a sugar remelter at St. James. Both worked well with good sensitivity and repeatability and without any plugging or scaling problems.

At this point, let's get a clearer idea of just how the Dynatrol works, and then we will discuss some of the present and potential applications. The Dynatrol density analyzer includes a density cell and a converter. The cell contains a stainless steel U-tube through which the liquid sample flows. The sample is extracted from the process at operating temperature and pressure, then returned to the process at some point of less pressure--pump suction or open tank. The U-tube is made to vibrate at its natural resonant frequency. As the weight of the U-tube changes, due to changes in liquid density, the frequency changes and is compared to a fixed frequency in the converter, which puts out a signal calibrated in density. A standard recorder-controller is used with a conventional control valve to complete the system. The range, such as 60 to 70 or 60 to 80 brix, is selected by dial setting on the converter, and this may be changed as required. Accuracy is $\pm .1$ brix.

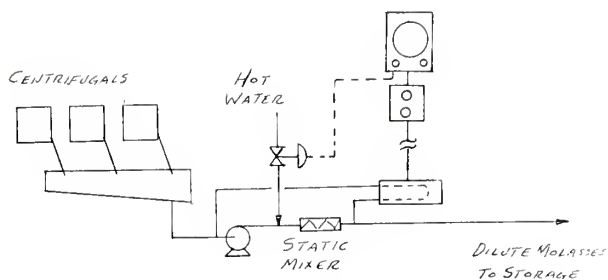
In 1974, several installations were made for recording or controlling syrup density from the last evaporator body and for in-line dilution of molasses from the centrifugals to A and B tanks. The syrup application requires only that a sample be taken off the pump discharge, going through the density cell and returning to pump suction, using short 1/2" pipe or tubing. The molasses dilution requirement entails one more step, and that is a static mixer to ensure a representative sample and to deliver thoroughly mixed molasses dilution to the tanks. Both applications are diagrammed in your copy of this paper (Fig. 1).

Density measurement has been found to be accurate and repeatable, with maintenance limited to periodic flushing in some cases and none in others. During regular boil-outs or caustic washing, the density cell and sample piping get flushed along with the rest of the system.

The automatic control part of these systems is still being refined, but it has been demonstrated to the fabricators' satisfaction that this system is workable. Evaporator syrup density control frees the operator for other duties while maintaining maximum production of uniform quality with minimum steam flow. In-line molasses dilution reduces the need for manpower up at the storage tanks, eliminates compressed air required for mixing during dilution at the tanks and the foaming problems caused by the compressed air, and presents a more uniform feed to the vacuum pans. Both applications reduce hand-sampling and lab time.



EVAPORATOR SYRUP DENSITY CONTROL



IN-LINE MOLASSES DILUTION CONTROL

Fig. 1. Evaporator syrup density control (upper figure) and in-line molasses dilution control (lower figure).

The initial success of this method during 1974 suggests increased usage in these two applications, plus other areas of automatic density control such as continuous preparation of lime slurry. The present method of manual batch make-up into large open agitated storage tanks could be replaced by an in-line automatic dilution controller delivering a constant Baume lime to the juice, with the flow rate controlled by pH. Lime make-up rate from bulk storage would be on demand from level control in the slurring tank. The density analyzer would control the water.

A further refinement of the liming process would be a static mixer as mentioned previously for in-line molasses dilution. The static mixer would be installed in the juice line on the pump discharge. Lime would be introduced at the juice pump, thus keeping the entire liming operation enclosed and at high velocity to prevent plugging, lime waste, and skin or eye irritation to employees. A uniform sample of limed juice for pH control would be taken off just downstream of the static mixer. No additional mechanical mixing would be required at the clarifier.

Other applications, such as automatic mud draw-off from the clarifier by density or percent solids for optimum clarification and filtration, have been suggested. We hope to set up a lime slurry make-up system and a mud draw-off system at one of the factories for demonstration during the 1975 grinding season.

PRELIMINARY REPORT ON THE 1974 FACTORY SCALE CORE STUDIES

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ELEMENTS OF A CANE SAMPLING SYSTEM

A system of cane quality evaluation for cane payment should include the elements of:

1. Removing an unbiased and representative sample from the consignment.
2. Preparation of the sample for processing.
3. Processing the sample.
4. Analyzing the processed sample.
5. Expressing the results in terms of a cane quality standard which forms the basis for subsequent cane payment and is a meaningful measure to both the grower and processor.

In implementing the above, the goal of an idealized system should be to:

1. Eliminate the judgement factor in selection and processing the sample.
2. Standardize the sample procurement and processing equipment.
3. Minimize personnel requirements.
4. Divorce the sampling system from the mill operation.
5. Reflect the effect of juice quantity as well as quality in cane.
6. Evolve a standard of cane quality which would indicate directly the recoverable sugar in the cane.
7. Provide data which supplements that of the routine factory control - for example fiber and sucrose % cane.

EQUIPMENT AND PROCEDURE

Cane Source. All cane used in this year's studies was obtained from commercial cane deliveries to Cinclare Central Factory during the 1974 crop.

Sample Procurement. The core samples were withdrawn from commercial cane deliveries using a J & L Model X-2 core sampler, fitted with a Rietz PB-10 prebreaker. Each sample weighed approximately 25-30 lb. The conventional samples were removed at the Cinclare sampling station using a mechanical grab on loads dumped on to the feeder table. Sucrose samples for grower were composited for grinding twice each day. Trash samples were not composited.

Sample Preparation. The core sample was fed automatically to the prebreaker by the corer. The individual shredded core samples were then mixed and sub-sampled, and sent to the core lab for analysis.

Extraction Apparatus. For the core samples, the Pinette-Emidecau Type OB-102 hydraulic press was used. A 1000 g cane sample was pressed for 5 minutes at 250 bars (3625 psig). The resulting juice and press residue were then weighed and analyzed. For the conventional samples, Cinclare's sample mill was used. It is an electrically driven, fixed setting, 3-roll sample mill with a nominal roll size of 11" x 10", with 3/8" opening on front rolls and 1/8" opening on back rolls (point to root). The factory extraction plant consists of one set of knives, a Stedman shredder, and four 3-roll mills of nominal size 38" x 84".

Analytical Techniques

Core: The bagasse weight after pressing was recorded. Bagasse moisture was determined using a Dietert Moisture Teller and drying to constant weight with air at 275 F. Juice brix was obtained using a Schmidt and Haensch refractometer fitted with a constant temperature bath (operated at the standard 68 F (20 C)). All juices were analyzed for pol using Horne's dry lead method and a Bausch and Lomb Polariscope.

Conventional: Growers composite samples were ground twice daily, and analyzed for brix using a hydrometer, and for pol using the standard method (same as core sample method).

Factory: The factory juices were analyzed by standard methods.

Procedure. Correlations between the core and the conventional method, and between each method and the factory were performed. All of the data were used for yield predictions, and the relationship between the core yield (lb sugar/gross ton) and the conventional methods yield (standard/gross ton) determined. The returns to individual growers over the period investigated were compared. The data and calculated results for the method comparisons were tabulated.

RESULTS

In general the core results correlated better with the factory results than did the conventional method. In particular the core sugar yield correlated better with the factory yield, than did the conventional standard to gross ton ratio with the factory yield.

Table 1. Correlation between sampling results and mill performance.

Relationship investigated	Correlation coefficient	
	Core	Conventional
<u>Core vs press (all data)</u>		
Core yield vs conventional yield	0.4851	0.4851
Core fiber vs conventional trash	0.0788	0.0788
<u>Sample method yield vs factory yield</u>		
Daily basis	0.6445	0.6107
Weekly basis	0.9022	0.8858
Sample method juice pol vs factory N. J. pol	0.7139	0.9035
Sample method juice purity vs factory N. J. purity	0.5448	0.5206

The press method is more responsive to variations in cane quality than is the conventional method. Good cane is valued much higher by the core method than by the conventional method. Bad cane is valued much less than it is by the conventional method. Average cane is valued the same by both methods.

Table 2. Comparison of yields by press and conventional method.

No. of sample	TRS range	Core		Conventional	
		Avg. TRS	Avg. CRS	Standard/gross	CRS*
1	100-110	109.5	91.4	0.9236	152.4
3	110-120	116.1	96.9	0.8467	139.7
10	120-130	128.6	107.3	0.8612	142.1
15	130-140	139.6	116.5	0.8211	135.5
19	140-150	144.1	120.2	0.9150	151.0
28	150-160	159.4	133.0	0.8605	142.0
45	160-170	162.7	135.8	0.8564	141.3
40	170-180	178.1	148.6	0.8873	146.4
48	180-190	187.2	156.2	0.8965	147.9
31	190-200	194.3	162.1	0.9739	160.7
20	200-210	202.3	168.8	0.9429	155.6
25	210-220	211.1	176.2	0.9792	161.6
10	220-230	222.2	185.4	0.9996	164.9
5	230-240	230.8	192.6	1.0199	168.3
2	240-250	245.7	205.0	0.9817	162.0
0	250-260	---	---	---	---
0	260-270	---	---	---	---
1	270-280	270.5	225.7	1.1123	183.5

NOTE: See Page 12 for definition of TRS and CRS.

*Calculated based on yield of 165.0 lb sugar/standard ton.

Individual growers would receive different payments for their cane over a period of time (4 weeks). But the differences were not as great as might be expected. However, the all grower payment would be the same.

Table 3 (a). Comparison of core and conventional sampling methods.

Shipper no.	Average daily delivery (tons)	No. of days	Core			Conventional		
			TRS	CRS	% C.V.	Std/gross	CRS	% C.V.
1	82	9	150.8	125.6	12.41	0.8691	142.2	10.89
2	75	6	157.0	131.0	16.49	0.9372	153.4	15.96
3	43	5	161.3	134.6	21.52	0.7375	120.7	31.22
4	45	6	163.0	136.0	17.07	0.8930	146.2	5.76
5	180	19	168.4	140.5	11.36	0.8200	134.2	15.46
6	231	10	168.7	140.8	9.43	0.8992	147.2	8.53
7	180	17	169.6	141.5	16.44	0.8893	145.6	12.84
8	669	4	171.1	142.8	6.34	0.8928	146.1	8.06
9	680	10	171.2	142.9	17.49	0.8946	146.4	13.21
10	199	8	172.5	143.9	5.50	0.8839	144.7	19.78
11	42	10	173.8	145.0	13.86	0.8992	147.2	13.32
12	149	12	173.9	145.1	17.85	0.8813	144.2	17.22
13	976	13	174.9	145.9	10.76	0.9140	149.6	10.09
14	389	15	175.4	146.4	19.02	0.9036	147.9	11.62
15	83	10	175.7	146.6	7.15	0.8589	140.6	13.65
16	30	8	178.7	149.1	17.69	0.9647	157.9	8.34
17	1028	6	179.2	149.5	4.94	0.8409	137.6	6.85
18	40	13	180.3	150.5	17.93	0.9577	156.7	11.17
19	42	7	183.6	153.2	14.54	0.8789	143.9	7.03
20	249	13	185.2	154.5	11.08	0.9269	151.7	7.85
21	41	8	185.6	154.9	11.13	0.9136	149.5	12.45
22	32	6	190.2	158.7	24.03	0.9399	153.8	5.35
23	63	6	190.9	159.3	19.62	0.9629	157.6	12.58
24	490	4	195.6	163.2	4.73	1.0144	166.0	9.00
25	44	9	197.0	164.4	12.76	0.9689	158.6	8.74
26	729	6	199.0	166.1	15.14	1.0465	171.3	9.53
27	45	4	201.3	168.0	23.17	0.9421	154.2	22.89

(Continued)

Table 3 (a). Continued

Shipper no.	Average daily delivery (tons)	No. of days	Core			Conventional		
			TRS	CRS	% C.V.	Std/gross	CRS	% C.V.
28	312	6	206.5	172.3	14.12	1.0069	164.8	11.40
29	84	9	207.1	172.8	8.68	0.9771	159.9	4.19
Simple Avg.	250		179.6	149.8	13.87	0.9143	149.6	11.90
Weighted Avg.			180.2	150.4	11.35	0.9188	150.4	10.46
% C.V.				12.05			6.80	

Table 3 (b). Comparison of predicted CRS by core and conventional sampling methods.

Core	Yield (lb gross ton cane)		Conventional*
	Core	Conventional*	
100		120.1	
110		126.0	
120		131.9	
130		137.9	
140		143.8	
150		149.7	
160		155.7	
170		161.6	
180		167.5	
190		173.5	
200		179.4	
210		185.3	
220		191.3	
230		197.2	
240		203.1	
250		209.1	

*Predicted CRS is based on the regression obtained from data in Table 3 (a).
 Conventional yield = 0.59 (core yield) + 60.74 (r = 0.7024)

Table 4. Data and results summary.

Date	Wt. Core cwt	Core							Conventional				Factory				
		TRS ¹ Gross ton	CRS ² Gross ton	% Fiber	Brix	Press Juice Pul	Purity	Std. Gross	% Trash	Brix	Sample Mill Juice Pul	Purity	Lbs. Gross (Daily)	Lbs. Gross (Weekly)	Brix	Normal Juice Pul	Purity
		lbs. Gross ton	lbs. Gross ton														
Nov. 14	92,834	194.5	162.3	18.57	17.00	14.62	86.00	1.0129	11.62	19.49	17.04	87.43	170.00	150.78	16.86	13.73	81.44
Nov. 15	50,618	184.4	153.9	20.26	17.26	14.58	84.47	0.9200	15.72	19.05	16.32	85.67	156.11		16.51	12.93	78.30
Nov. 16	89,703	195.2	162.9	19.08	17.30	14.86	85.90	0.9642	13.43	19.00	16.64	87.58	163.61		16.45	13.06	79.40
Nov. 17	63,388	179.8	150.0	19.27	15.91	13.75	86.42	0.8409	17.24	18.57	15.80	85.08	150.53		16.00	12.71	79.43
Nov. 18	80,895	167.1	139.4	20.77	15.56	13.26	85.22	0.8686	18.88	18.41	15.82	85.93	156.29		15.96	12.69	79.50
Nov. 19	66,330	175.4	146.4	18.79	15.74	13.36	84.88	0.8546	18.73	18.16	15.53	85.52	144.30		15.65	12.21	78.52
Nov. 20	70,917	159.6	133.2	21.94	15.35	13.04	84.95	0.8656	20.26	18.68	16.00	85.65	145.06		16.09	12.74	79.16
Nov. 21	49,942	-	-	-	-	-	-	0.9098	20.00	18.98	16.59	87.41	129.59	150.56	16.34	12.69	77.67
Nov. 22	66,427	181.3	151.3	19.35	16.64	14.05	84.44	0.9506	14.93	19.05	16.53	86.77	161.51		16.41	13.01	79.30
Nov. 23	47,452	188.0	156.9	17.83	16.51	14.03	84.98	1.0452	11.72	19.70	17.34	88.02	165.65		16.97	13.29	78.99
Nov. 24	37,927	185.0	154.4	18.99	16.26	14.03	86.29	0.9880	10.02	18.64	16.30	87.45	150.75		16.05	12.71	79.19
Nov. 25	54,264	171.5	143.1	18.71	15.55	13.10	84.24	0.9425	12.11	18.44	16.08	87.20	139.31		15.88	12.54	78.96
Nov. 26	68,814	175.0	146.0	19.27	15.95	13.51	84.70	0.9143	14.21	18.57	16.10	86.70	144.96		15.92	12.51	78.56
Nov. 27	64,221	192.4	160.5	17.61	16.64	14.25	85.64	0.9443	16.22	18.21	15.62	85.78	157.35		15.62	12.51	80.11
Nov. 28	60,817	179.5	149.8	18.85	16.63	13.75	84.70	0.8992	16.13	18.63	16.16	86.74	141.43	152.51	15.78	12.48	78.08
Nov. 29	63,850	193.1	161.1	17.52	16.79	14.28	85.05	0.9168	12.67	18.37	15.85	86.78	156.71		15.75	12.38	78.57
Nov. 30	65,344	-	-	-	-	-	-	0.8338	20.05	18.17	15.80	86.96	130.97		15.59	12.22	78.36
Dec. 1	51,676	-	-	-	-	-	-	0.8722	15.09	18.47	15.90	86.09	143.56		15.84	12.31	77.72
Dec. 2	67,302	-	-	-	-	-	-	0.9113	14.77	18.28	16.00	87.53	147.19		15.68	12.28	78.31
Dec. 3	57,101	176.8	147.5	19.39	16.22	13.67	84.25	0.9297	15.70	18.70	16.51	88.29	154.73		16.08	12.63	79.33
Dec. 4	64,677	163.5	136.4	21.43	15.97	13.38	83.78	0.9215	13.14	18.41	16.14	87.67	141.79		15.34	12.31	77.72
Dec. 5	75,409	164.4	137.2	18.68	15.33	12.72	87.77	0.9712	11.33	18.06	15.62	86.49	152.86	146.97	15.34	12.14	78.12
Dec. 6	67,682	171.7	143.3	17.48	15.21	12.77	84.05	0.9449	13.12	17.69	15.11	85.42	148.40		15.22	11.82	77.65
Dec. 7	70,767	157.1	131.1	15.07	13.57	11.22	82.68	0.9092	21.41	18.21	14.63	80.34	125.98		15.66	11.63	76.62
Dec. 8	43,509	181.1	151.1	16.90	15.39	13.19	84.71	0.7621	21.82	17.36	14.98	86.29	126.54		14.93	11.36	76.06
Dec. 9	71,594	166.0	138.5	19.22	15.17	12.72	84.25	0.8566	18.43	17.99	15.64	88.05	142.30		15.49	12.00	77.48
Dec. 10	72,353	177.4	145.0	15.56	15.44	12.77	82.64	0.8534	14.92	17.61	15.04	85.41	149.04		15.10	11.80	76.85
Dec. 11	77,471	185.6	154.9	17.23	15.85	13.61	85.87	0.8271	18.08	18.20	15.53	85.33	164.19	141.81	15.61	11.97	76.66
Simple Avg.	-	177.7	148.3	18.66	15.96	13.53	84.75	0.8920	15.80	18.47	15.96	86.40	148.59	-	15.89	12.45	78.32
Weighted Avg.	-	177.6	148.2	18.67	15.95	13.52	84.74	0.8908	15.80	18.47	15.95	86.35	149.46	148.2	15.70	12.46	78.37

¹ TRS - Theoretically recoverable sugar.

² CRS - Commercially recoverable sugar (TRS factored to Actual Factory Production).

³ Indicates that less than 80% of delivered cane was sampled due to bad pavement condition under core sampler installation.

CONCLUSIONS

The core sampling system meets the requirements of an ideal cane sampling system better than does the conventional method.

Core labor requirements are about half that required by the conventional system, (4 vs 8 people), while equipment cost of corer is about four times that of conventional method (\$60,000 vs \$15,000). Possibly a separate lab building might be needed for corer - for convenience.

CORE SAMPLING RESULTS (1972-1973)

Outlined below are the highlights of a 3-year investigation of core sampling in Louisiana.

The 1972 studies showed that 1) the core sampler extracts a representative and unbiased cane sample regardless of point of coring in the load; 2) the juice from the core sample was more closely related to the factory normal juice than was that obtained from the conventional method operated under ideal conditions; 3) the core sample showed a fiber % cane value very closely related to that of the factory. On the other hand, the trash determination of the conventional system bore very little relationship to the factory fiber % cane.

The 1973 studies showed that 1) the hydraulic press was extremely reproducible. The difference between the predicted sugar from replicate determinations was only about $\pm 1\%$. 2) the hydraulic press pol extraction of over 70% was much closer to the 90% pol extraction achieved commercially, than are the pol extractions of sample mills (usually about 50%). 3) The pol % cane figure obtained by use of the hydraulic press was within 2% of the value obtained by the direct cane wet digestion method (the most accurate method available--but very time-consuming). 4) The hydraulic press responds to trash in the same manner as do mills. The hydraulic press fiber figures for trash are in direct proportion to the load and extraction effect that the trash imposes on the mill. Thus, green leafy trash only lightly loads the mill, while dry leaves load the mill greatly, with field soil falling between these extremes.

The 1974 studies confirmed earlier findings and showed that 1) the core sampling method more accurately predicts the factory recoverable sugar than does the conventional method. 2) That the recoverable sugar in the cane by the conventional method only gives the growers about 60% of the premium value for cane above standard quality, and conversely only penalizes growers 60% of the penalty value for cane below average quality. Thus the conventional system falls about midway between a cane payment system based on cane quality (recoverable sugar basis) and a flat rate system (no account for cane quality) (See Tables 2 & 3). 3) Because of variations in cane quality by a single shipper over a period of time, the final payments for an entire crop by the two sampling methods are not as great as might be expected (See Table 3). 4) The apparent fiber (insoluble dry solids) in cane is greater than most factories report. Fiber % cane averaged 18.67% in typical weather conditions. This, of course, is determined on unwashed cane. 5) The theoretical recoverable sugar from delivered cane was about 30 lb sugar/gross ton cane greater than that reported by the factory. Of this 30 lb/ton about 5-10 lb/ton can be attributed to simplification steps and assumptions used in the core-press recoverable sugar predicting formula employed. However, the other 20 lb/ton appears to have been lost between the cane scale and the factory mill by: the stockpiling of cane, damaging cane by mechanical yard handling equipment, clean-up operations in the factory yard, and cane washing operations.

This raises a question that requires future investigation. At the same time it shows the value of a cane sampling system that is entirely independent of factory operations, and thus can function as a double-check on the mill control.

It should be pointed out that Cinclare's factory operations are normal, and that their factory efficiency and yield are typical of factories in the area. This higher sugar yield predicted for cane as delivered is not unusual. The USDA Houma station, and the Audubon Sugar Factory at LSU confirm that the recoverable sugar from fresh, unwashed cane is generally much greater than that which the commercial factories achieve.

In conclusion, the author believes that the core-press system is now ready and desirable for implementation in Louisiana. It will achieve the incentive system that the conventional system was intended to achieve, while at the same time fulfilling other desirable requirements of an ideal cane payment system.

Finally, a plea is made for Louisiana to join the progressive sugar world in using absolute juice in place of normal juice, the refractometer in place of the brix spindle, and the installation of

accurate juice, imbibition (maceration), bagasse, sugar, and molasses weighing systems. These are invaluable for ascertaining factory efficiency, leading to improved operation and control, as well as serving as useful tools in implementing an equitable cane payment system.

DATA REDUCTION FOR TRS AND CRS - Core

Data required: bagasse % cane, bagasse % moisture, juice pol, and juice brix. Assuming juice remaining in bagasse is same composition as juice extracted we get: Juice % bagasse = $\frac{\text{bagasse \% moisture}}{(1 - \text{juice brix})}$ 100

Fiber % bagasse = 100 - juice % bagasse. Now, fiber % cane = F = $\frac{\text{bagasse \% cane} \times \text{fiber \% bagasse}}{100}$

Juice % cane = 100 - fiber % cane. Brix % cane = B = $\frac{\text{juice \% cane} \times \text{brix \% cane}}{100}$. Pol % cane = S = $\frac{\text{juice \% cane} \times \text{juice \% pol}}{100}$.

Yield Calculation: TRS yield (lb 96° sugar/gross ton cane) = $\frac{2000 \times \text{pol \% cane} \times \text{extraction} \times \text{retention} \times 1}{100 \times 0.96}$, where: Extraction is assumed dependent on fiber % cane. A constant reduced extraction (extraction at 12.5% fiber) is assumed.

Extraction = $\left[100 - \frac{(\text{abs. juice in bag. \% fiber}) \times (\text{fiber \% cane})}{100 - \text{fiber \% cane}} \right]$. Retention is obtained using

Winter-Carp formula, with an assumed BHE of 96, i.e. retention = $\left[1.4 - \frac{40}{P} \right] \times 96$, where P is the absolute juice purity.

Assuming a reduced extraction of 91.9, the yield expression reduces to TRS yield (lbs 96° sugar/gross ton cane) = $(0.28S - 0.08B) \left[100 - \frac{56.67F}{100-F} \right]$, where F is the fiber % cane, S is the sucrose % cane, and B is the brix % cane.

CONVERSION OF TRS TO CRS

TRS = theoretical recoverable sugar (lb 96° sugar/gross ton cane)
 CRS = commercial recoverable sugar (lb 96° sugar/gross ton cane)
 RS = recoverable sugar (factory) (lb 96° sugar/gross ton cane)

CRS = TRS x F, where, the liquidation factor, F = $\frac{RS}{\sum TRS}$

A REVIEW OF WET SCRUBBERS AT JEANERETTE SUGAR COMPANY

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INTRODUCTION

The purpose of this paper is to give a general outline of the installation of wet scrubbers on 3 bagasse-fired boilers at Jeanerette Sugar Company during 1974. The scrubbers were selected by a consultant, Mr. William Boulet, of New Orleans, LA, and were supplied to us by the Ducon Company of Mincola, N.Y. The concrete foundation, steel erection, and installation of the units were accomplished using labor supplied by a local consultant firm working under my supervision. Because of the large amount of construction in process at the time, the scrubbers were not put on stream full time until October 28 (about 14 days after the start of the crop). The units operated continuously from this date until the crop was over December 31. We experienced some downtime due to power interruptions causing the overload relays to cut out, and trash in the bayou water we were using plugging the main water nozzles (see conclusion).

DESCRIPTION OF INSTALLATION

The flue gases from 3 out of 5 boilers are presently ducted into a common breeching which carries them to a natural draft stack. At a point in the breeching between the entry of the last boiler flue gases and the stack, a large transition duct was installed. This duct takes the combined flow of 3 boilers and splits it in half, delivering approximately equal volumes to 2 Ducon UW-4 dynamic gas scrubbers. These 3 boilers have no other dust control equipment, and no air preheaters, i.e. the stack gases pass directly from the boilers into the wet scrubbers. Dampers installed at the entrance to the natural draft stack and in the inlet of both scrubber units allow the flue gas stream to be directed to either the scrubbers or to the stack when the units are off the line. Each scrubber has a 150 HP paddle wheel type fan which supplies both the internal centrifugal action and induced draft for the boilers. The fan also acts as a water atomizer because all of the scrubbing water is admitted directly into the fan impeller.

The unit's triple scrubbing action is as follows: The soot laden gases enter the lowermost pre-cleaner section tangentially, resulting in a cyclonic flow. Water falling from the sections above mixes with the gases here, cooling them drastically. The water and heavier particles are thrown to the sides of the unit by centrifugal force, where the dirty water drains down to go out the slurry outlet. The largest and heaviest particles are thus removed here by water from above which has already captured the fine particles.

The gases next pass through a scrubbing vane up into the middle section of the unit. This vane increases wetted surface area for particle impingement and imparts more cyclonic movement to the gases. The gases are now drawn by the fan out of this section into the fan duct riser. The scrubbing water is introduced into the eye of the fan, causing complete flushing of all fan impeller surfaces. Fine particles are then captured by: a) Turbulent mixing of gases, liquid, and particles, b) impact of rotating wetted blades on fine dust particles, and c) impingement of dust particles on the moving layer of water on the walls of the fan housing.

The fan discharges tangentially into the final water eliminator section, where droplets are formed and thrown against the wall to descend to the lower section. Gases free of liquid droplets discharge vertically through the scrubber outlet.

The ash slurry is discharged out of the conical bottom by gravity into a surge tank. A barometric seal is effected by having the outlet pipe at least 12 inches under the surface of the slurry water. Fresh bayou water was used as the scrubbing liquid and is not recirculated. The slurry is pumped out of the tank by a rubber lined centrifugal pump to a retention pond 6000 ft away from the mill. It is held here along with water from filter press mud slurry and cane wash water.

TECHNICAL DATA

A comparison of design specifications with actual observations while operating is as follows. Data represent total for both scrubber units, and measurements are approximate.

		DESIGN	MEASURED
1. Gas inlet			
Temp.	°F.	650	430
Static pressure	in. W.G.	2.5	1.6
Volume	ACFM	113,400	-
2. Gas outlet			
Temp.	°F.	163	145 ⁽¹⁾
Volume	ACFM	74,812	133,200 ⁽¹⁾
Particulate emissions	lb/hr.	-	22.1 ⁽¹⁾
3. Water in			
Temp.	°F.	-	60 to 80
Volume	GPM	240	237
Pressure ⁽⁵⁾	PSI	15	20
4. Slurry out			
Temp.	°F.	-	130
Volume	GPM	-	211
Solids	%	-	.5 ⁽²⁾
5. Fan motor current	AMPS	175 ⁽³⁾	145 ⁽⁴⁾
6. Boilers (#1, 2 & 3)			
Steam rate	lb/hr.	90,000 (Rating)	
Max. heat input	BTU/hr.	150 x 10 ⁶ (Estimated)	

(1) Stack tests by Ecology Audits, Dallas, Texas, December 18 & 19, 1974.

(2) % by volume

(3) Nameplate current, each motor

(4) Each motor

(5) At nozzles

CONCLUSIONS

The operation of the wet scrubbers was entirely satisfactory in regards to their ability to remove a very high percentage of the solid particulate matter in the stalk gases of these 3 boilers. The units operated without any noticeable change in the outlet plume during the entire crop, regardless of variations in amount or quality of bagasse burnt. There was no carryover of drops of water into the outlet plume, and consequently no fallout around the units. Results of stack emissions tests of December 18 and 19, show total particulate emissions of 22.1 lb/hr during the tests. It appears then that the rate of emission during the tests is below the state allowable of .6 lb of particulate matter per million BTU of heat input to the boilers. The outlet plume of water vapor was so constant during the season that I am sure that tests on other days would yield approximately the same results.

The downtime which we had on the units was attributed to the following:

1. On several occasions, heavy rain caused some water to get into the electrical disconnects on the 150 HP fan motor circuit. This caused shorts which tripped the overload relays. Some screw-type lug connectors vibrated loose causing the same thing to happen. Proper torque on these lugs and sealing of the electrical enclosures stopped these problems. Also short power outages of the local electrical company caused the motors to shut off at times. It seems that steam driven fans would offer a more reliable and trouble free fan drive system.

2. The scrubbing water was being taken directly out of the bayou and pumped to the nozzles. The lack of a screening device in these lines allowed trash to plug the nozzles, requiring cleaning about once a week. Trash also plugged the screen on the foot valve on the suction pipe, causing a loss of water pressure. When this happened, a pressure switch cut off the pumps and the fans. The scrubbers were taken off the line then to clean these areas and then put back on. This was

undoubtedly our largest problem, and should be solved next year by using condenser water and installing adequate screening systems.

An inspection of the insides of the unit after the season was over showed the following:

1. The blades of the fan were worn on one corner to about 1/16 inch thick from their original 1/4 inch thickness. We will weld a 1/4 inch thick mild steel plate liner to the face of these blades and expect to get a full season for these liners. Obviously, thicker liners, special steels, and abrasive resisting coatings would prolong the life of the liners.
2. A manhole located at the back of the fan wheel had one edge worn through until a pin hole appeared. This can be repaired with a strip of flat bar approximately 3 inches by 18 inches. Refitting the manhole so that it is flush on the inside of the fan housing should eliminate this wear area.
3. The lower or inlet sections of the units show some wear both on the shell wall and on the stationary impingement vanes. The vanes will be repaired by welding new sections in, and hard surfacing the edges. The worn section of the shell will be repaired by either lining these areas with plate or spraying with a urethane or rubber coating.

The rubber lined slurry pump failed about one week before the season was over. After looking at the insides of the pump, the manufacturer's representative seems to think that a piece of steel worked its way into the pump, ruining the liner. This pump will be relined and put back into service for next year.

We may also increase the speed of the fans on the scrubbers some in order to get more draft on the boilers. When the bagasse was dirty and wet toward the end of the season, we did not seem to have enough draft on these three boilers.

We will put the scrubbers back into operation next year without any changes other than those outlined above.

RAW SUGAR MARKETING IN A CHANGING ENVIRONMENT

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Farr Man and Co.

Although we have been invited here today to discuss the topic of hedging, hedging itself is but a small part of a much larger topic called raw sugar marketing.

Traditionally, producers and processors have been totally concerned with production. As we enter 1975 without sugar legislation, the industry, in addition to production concerns, must contend with the problems of raw sugar marketing. No longer does the corridor mechanism or any other form of agreement stabilize prices within a reasonably defined area. It is in the context of raw sugar marketing that we discuss hedging.

In any discussion of hedging, it is helpful to explore not only how a hedging program is developed and implemented, but also to understand the theory behind hedging.

By definition, hedging involves forward sales of physical sugar or futures against anticipated production. The purpose of hedging is to fix a price in order to secure a profit or limit a loss prior to the time production is ready for shipment to the processor or refiner.

Some quarters have often criticized hedging of either the physical product but particularly the sale of futures as speculation. The definition and role of the speculator is entirely different. The speculator and speculation involve anticipatory activities. The speculator typically buys or sells in the hope of being able to unwind or liquidate his position at a profit. He has no interest in the physical product, and has absolutely no intention of delivering or receiving any portion of the physical commodity. The producer or processor is in an entirely different position and, unlike the speculator, is always at risk. The speculator does not have to place himself at risk. He does not have to buy or sell but can choose to stay on the sidelines, to stay out of the market. The producer or processor does not have this luxury. He is inherently long the market, since he has control of or will eventually control the physical product. He should always be conscious of his vulnerability to price declines prior to the beginning of his pricing period or during his pricing period.

We at Farr Man strongly disagree with the view that future sales are speculation. The production and processing of sugar are commercial enterprises and there is a need to limit risks whenever possible. Your business is insured against fire, theft and accident, so why not insure your product against price declines? In fact, one speculates by not doing anything since he is assuming the market will remain at current levels or move higher. We have not endorsed the policy of doing nothing in the past nor will we in the future.

In summing up the theory behind hedging, it is simply to reduce commercial risks by making forward sales to fix a price.

This brings us to the mechanics of a hedging program. While forward fixed price sales of actuals are popularly viewed as hedges, in reality they are not. More properly, they are final sales to industrial users or refiners which will not be liquidated. While many producers and processors favor this route, there are some drawbacks. Where there are no original margin or variation margin requirements involved as there are in future transactions, the seller's flexibility is all but eliminated.

For the most part, we prefer using the futures market to execute hedging programs for our clients. The futures market is a place where all interested parties - producers, processors, dealers, refiners, manufacturers, etc. - may buy and sell raw sugar for future delivery.

There should be no mystery about a futures market. The New York Coffee & Sugar Exchange is basically no different from any other market in the world where goods are traded. There, anyone can buy or sell sugar for delivery at any time up to 18 months. The fact that speculators are also operating within the market does not change the fundamental facts. The speculator is attracted to the market by the risk/reward factor. The trade wants him there and, in fact, finds him essential to give breadth and liquidity to the market. Members of the trade feel their role is to stick to their own speciality and not to assume market risk. They are delighted when the speculator enters the market and takes some of the burden off their shoulders.

I think it might be interesting and helpful to discuss briefly the organization of The New York Coffee & Sugar Exchange, Inc. It is a typical commodity exchange.

The Exchange is a non-profit corporation chartered under the laws of the State of New York; it functions under by-laws and rules which are established by the membership. It is governed by a board of managers and officers elected by the membership. A paid president runs the Exchange under their auspices.

Memberships in the Exchange may be bought or sold, and individuals are elected to membership by the board of managers only after having met stringent standards.

The Exchange itself does not buy or sell anything. It maintains a marketplace at 79 Pine Street, New York, N.Y. where floor broker members trade in coffee and sugar futures contracts. Part of the responsibility of the President is to see that trading in futures contracts is accomplished by open outcry in accordance with by-laws which have been approved by the membership and rules, regulations and resolutions adopted by the board of managers.

Two types of sugar futures contracts are traded on the Exchange. The world sugar contract, Contract No. 11, provides for delivery of raw sugar at a loading port designated by the seller, or deliverer, in any one of 29 designated foreign cane producing countries. Delivery is made to a vessel chartered by the buyer or receiver. The buyer may sell the raw sugar in a market chosen by him except that he may not sell the sugar in the United States for human consumption so long as the Sugar Act is effective. The contract price is expressed in cents per pound, f.o.b. and stowed, at a foreign loading port.

The domestic raw sugar contracts are Contracts No. 10 and 12. Contract No. 12 provides for delivery at a cane sugar refinery, designated by the buyer located in New York, Philadelphia, Baltimore or New Orleans. The contract price is expressed in cents per pound, duty paid, delivered.

The unit of trading in each sugar contract is 50 long tons. The minimum fluctuation is 1/100th of a cent with the value of this fluctuation being \$11.20 per contract. If sugar futures are sold or bought and are not liquidated prior to the last trading day, the seller must deliver and the buyer must receive actual raw sugar under the specific terms and conditions set forth in the by-laws and rules of the Exchange. Because nearly all trading in sugar futures is for price protection and not for the purpose of buying or selling actual raw sugar, only a small percentage of futures contracts are held until delivery time. Some deliveries, however, are made against sugar futures contracts. Therefore, provisions are made in Exchange rules to cover the possibility of default, even though the Exchange has never experienced a default in its 90 year history.

One of the very important features in Exchange transactions is the clearing house - The New York Coffee & Sugar Clearing Association, Inc. This is the institution through which the fulfillment of contracts is guaranteed. It becomes a party to all transactions. House A may have sold to House B on the Exchange. The Clearing Association becomes House A's buyer and House B's seller.

This guarantees the integrity of the contract because of the safeguards under which the Clearing Association operates. First, each member firm of the Clearing Association deposits a specified amount of money to create a guarantee fund. In the event of a member firm failure, losses are paid out of the guarantee fund and out of any surplus which may have accrued. If these funds are not sufficient to meet the obligations, member firms are assessed to make up the difference. In other words, a contract made on the Exchange is backed, not only by the two parties to it, but by every member of the Clearing Association.

Also, the Clearing Association performs a critical surveillance function. At the end of each business day, each Clearing member is required to report any and all transactions during that day as well as its position in each month of every contract. These procedures effectively rule out a situation similar to the one which occurred on the Paris Exchange where one clearing member managed to accumulate over fifty percent of the outstanding contracts. The clearing member's failure precipitated the collapse of the Paris Exchange and has placed that Exchange's future in grave jeopardy.

In addition to the protection mentioned above, each member firm must maintain margins with the Clearing Association at all times against its outstanding contracts. This includes both the original margin required when the contract is entered into as well as variation margin which may be required if the market moves counter to the position established. It should be noted that margins have nothing to do with controlling price fluctuations. The amount of margin required represents the judgment of the experienced businessmen who govern the Exchange and the Clearing Association as to what is necessary to guarantee fulfillment of a contract. Although the Exchange sets minimum margin requirements, Clearing members may require amounts in excess of the minimum as they see fit.

Flexibility is the key in setting up a hedging program. Taking a percentage of a client's production (last year this figure ranged between 25% and 33%) we would enter orders to sell futures on a scale up, to take advantage of bulges or spurts in futures prices. If the market declined 10% from any target area, we would enter sell orders for execution at this lower level. Our purpose was to lock in that portion of a producer's or processor's production at a fixed price which would cover all costs and return a desired profit. As with all future contracts, original margin, in essence a deposit, was required and as the market advanced, variation or maintenance was required to maintain the original margin figure.

Hedging takes on a schizophrenic posture. Since only a portion of production is normally sold, you are asked to jump for joy while you lose your shirt in an up market as your unhedged portion of production increases in value. This is probably the most difficult aspect of hedging to explain. Incurring large paper losses on futures sales and putting increasing amounts of cash up to meet calls for variation margin is not supposed to be therapeutic or enjoyable. Please bear in mind, however, that any increases in value and, more importantly, vice versa.

We find ourselves returning again to the idea of flexibility and again to 1974 for an example. During July when we felt there was the possibility of significant price declines, we encouraged many of our producing and processing clients to sell futures contracts against anticipated production as a form of insurance.

When it became evident that the fundamentals were changing, especially a poorer than expected European beet production which might significantly affect world sugar prices and consequently domestic prices, we recommended partial repurchase of short hedges. When more information became available, we recommended lifting all remaining hedges with the intention of reselling at a later date. We have not recommended any rehedging as yet, but my point is the flexibility is there. Losses were incurred in repurchasing hedges, but these losses were offset long ago by higher raw sugar prices.

Some producers and processors have used the world market for hedging purposes. While we have discouraged this idea in the past, circumstances in 1975 may alter our thinking. In the past, actions by the USDA which were intended to bring U.S. prices down by drawing sugar out of the world market and into the U.S. market have affected world market prices from time to time. With no such actions likely next year, the world market and the liquidity inherent in the #11 contract may well provide an attractive outlet for hedges. With rough differential existing between the #11 and #12 contracts taking into account duty and freight, it may make good sense at times to establish hedge positions in the #11 contract which may eventually be switched to the #12 contract when the differential warrants.

If I were free to make one observation, it would be that it will be absolutely necessary for producers and processors to work together this year. In the absence of a Sugar Act, no longer will pricing options between producers and processors be limited to one of the traditional average methods. While there are definite merits to using one of the averages as the basis for payment, producers will now be free to enter into any mutually agreeable method with processors. This includes a fixed price sale to a processor which was not permitted under the Sugar Act. While this may be very attractive for the producer, the processor is the one who may find himself caught in the middle. If the processor agrees to purchase cane at a fixed price, how does he protect himself? How will he ultimately settle with the refiner? These are very difficult questions.

Perhaps it would be best if we start at the producer level and work up the line from there.

As we have said, the producer may now sell his cane to a processor at a fixed price. In the absence of agreement on the fixed price, however, the producer may sell all or any part of his production in the futures market at his discretion. When he is able to reach an agreement with a processor on pricing terms, he may then buy back his futures.

The producer and processor may choose the against actuals, or AA, method which we discussed with several processors last year. Under this arrangement, producer and processor agree on a fixed quantity of raw sugar to be delivered during a particular period. Each party enters the futures market in a particular month or months to buy in the case of the processor or sell in the case of the producer at his discretion. Each party having eventually concluded his pricing, we now have the producer long sugar and short futures, and the processor long futures and short sugar. On a mutually agreeable date, the parties will unwind these transactions through an AA which is simply a swap. In return for his sugar, the producer receives the processor's long position to liquidate his short position. The AA price is immaterial and the transaction is included in the records of The New York Coffee & Sugar Exchange as a matter of course. In essence, an AA is a prearranged trade between the two parties involved. Its beauty is that it gives both parties maximum flexibility in pricing while avoiding any problems with respect to the liquidation of futures positions.

There are variations to this theme which may appeal to some. For example, the producer may sell contracts for the processor's account. The processor would enter the market to reacquire contracts so as to establish his cost price. The futures sales price less a mutually agreed upon discount reflecting futures carrying charges absorbed by the processor would be remitted to the producer. Any difference between the purchase and sale of futures would be for the processor's account. It is of no consequence whether the producer or processor is the first to enter the market; the outcome is still the same.

A second variation would be for the producer and processor to agree on a price. If the processor felt he paid too much, he could sell all or any part of the quantity and hopefully buy the contracts back at a profit and thus reduce the cost of his sugar. If the producer felt his selling price was too low, he could buy all or any part of the quantity and hopefully sell these contracts at a higher price and thus raise his net selling price.

The processor would appear to be the one caught in the middle. The methods we have proposed for the producer would appear to make equally good sense from the processor's standpoint. Each would appear to put the processor on equal footing with the producer. Neither would stand to gain at the expense of the other as both parties would be acting in the futures market independently of each other.

In the past, however, the processor has attempted to place the producer on the same basis as he in settling with the refiner. He is thereby eliminating a substantial portion of his risk as he should properly attempt to do. While we are in no position to speak for refiners with respect to their ideas on pricing, any discussions between producer and processor should be tempered somewhat from the processor's standpoint. Unless or until he has some idea as to what his pricing method will be with the refiner, he should proceed with caution lest he find himself settling with the refiner and producer on different terms. This difference could place the processor at risk at a time when we are attempting to devise ways to limit or eliminate such risks.

Keep in mind, however, any futures transactions will involve original margin as well. Financing becomes a significant factor. Louisiana producers and processors are fortunate to have such agencies as the Production Credit Association and the Bank for Cooperatives which have funding available for hedging purposes at favorable rates. They are to be commended for their foresight and support.

We are moving into an extremely difficult period. To the burdens of production, you will now have to concern yourselves to a much greater degree with raw sugar marketing. Given instability and sharp fluctuations as the U.S. market is incorporated and increasingly subjected to the gyrations of the world market, planning will be difficult. We would urge you to maintain your flexibility this year and to give every consideration to futures hedging. We would also urge you, however, to reserve the right, on the basis of information at hand indicating a change in fundamentals, to unwind or alter your hedging program strategies accordingly.

With this new concern over marketing comes the challenge and with the challenge the opportunity. The domestic cane industry has successfully met the production challenge and continues to seek new avenues to greater production. Should this new challenge be any different? Farr Man looks forward to participating with you in this challenge. Given exposure and experience, the industry will successfully master marketing and will become a stronger and healthier industry for it.

Farr Man looks forward to the privilege of working with all segments of the domestic industry to develop innovative and productive pricing methods. A stronger domestic industry is absolutely essential if the U.S. is to manage while still importing nearly 50% of its needs. Given an abnormally low world stock or carryover figure and a precarious production/consumption equation, raw sugar prices are liable to fluctuate drastically during the coming months and possibly years.

Farr Man believes an enlightened domestic industry, poised to take advantage of marketing opportunities, will fare very well indeed.

PRICING EXAMPLES

Quantity involved is 1,000 long tons of sugar equivalent to 20 futures contracts @ 50 long tons per contract.

- AA Method -

Processor

Buys 20 contracts .40
Short sugar, long futures

AA (swap) price .50

Pays .50 for sugar
Sells futures at .50
Sugar cost .50 minus futures
profit .10
Equals net cost .40

Producer

Sells 20 contracts at .60
Long sugar, short futures

Sells sugar for .50
Pays .50 for futures
Sugar proceeds .50 for futures
profit .10
Equals net selling price .60

- Processor's Account -

Processor

Buys 20 contracts at .40

Processor pays producer .60 for sugar less agreed upon discount. Raw purchase price offset by .20 profit realized from futures transactions

or

Buys 20 contracts at .60

Since contracts are sold for the account of the processor, processor pays producer .40 less discount while absorbing futures loss of .20.

Producer

Sells 20 contracts at .60

Sells 20 contracts at .40

- Fixed Price -

Processor pays producer .50 while current market price .50

Processor sells 20 contracts at .50
Processor buys 20 contracts at .40
Processor reduces cost price to .40

Producer buys 20 contracts at .50
Producer sells 20 contracts at .60
Producer raises net selling price to .60

GROWTH REGULATORS TO INCREASE
SUCROSE IN SUGARCANE^{1/}

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ABSTRACT

Eight field experiments with growth regulators were conducted from 1972 to 1974. Of the 15 growth regulators tested as sugarcane ripeners, N,N-bis-(phosphonomethyl)glycine, Polaris, was the most promising in increasing yield of sugar/acre. However, overall response to Polaris and other ripeners was highly inconsistent. Response appears related to variety, age of cane, time and rate of application, climatic conditions before and after application, and the interval between application and harvest. Possible deleterious effects of growth regulators on the subsequent stubble crop following harvest are also discussed.

^{1/}Research at this location is done in cooperation with the Louisiana Agricultural Experiment Station.

A COMPARISON OF THE MASSEY FERGUSON 102 COMBINE TO THE CONVENTIONAL LOUISIANA HARVESTING SYSTEM

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Several manufacturers of conventional Louisiana harvesters are experimenting with cut-chop harvesters for use in Louisiana. When the South Coast Corporation decided to use a Massey Ferguson 102 chopper harvester during the 1974-crop harvest, it provided an opportunity to study a production model chopper harvester under Louisiana conditions. The Massey Ferguson 102 cuts cane into pieces about 12-16 inches long and drops these pieces into a cane wagon pulled along side the harvester.

PURPOSE OF STUDY

The general purpose of this study is to compare the Massey Ferguson 102 harvest system with the conventional Louisiana harvest system. The following comparisons are made between the two systems: (1) cane quality, (2) field losses of cane (scrap) (3) harvesting and loading costs, and (4) hauling costs. I will present the data pertaining to harvesting and loading costs, and hauling costs.

HARVESTING AND LOADING COSTS

Costs were determined for representative makes and models of equipment needed to harvest and load cane under each system. An initial investment cost of each equipment item was determined, based on January 1975 prices. This was the approximate total purchase price, including 5% sales tax. A Louisiana price for the Massey Ferguson 102 has not yet been set. An estimated price was determined after speaking to Massey Ferguson representatives.

Fixed and variable costs for each piece of equipment were determined and converted to an hourly cost basis. Fixed costs are overhead costs which do not vary with the amount of use of the item. Variable costs are those that increase in proportion to the use of the item. Fixed costs include depreciation, interest on investment, insurance, and shelter. Variable costs include repairs and maintenance, tires, fuel, engine oil, and operator's labor.

Work standards for each equipment item are shown in Table 1. This is the amount of output that each equipment unit can consistently produce in a given time period with good management. Using these work standards, a cost per ton was determined for each equipment unit.

Table 1. Work standards and hourly cost of various equipment items.

Equipment	Work standard (Gross tons/hour)	Cost/hour (\$)	Cost/ton (\$)
Massey Ferguson 102	20	43.658	2.183
Thomson Harvester	27	25.377	.941
Cameco Loader	55	11.150	.203
Conventional Hauling Unit	21.89 ^{1/}	10.470	.478
M. F. 102 Hauling Unit	12.90 ^{2/}	10.560	.819

^{1/}Based on these assumptions: (1) hauling unit road speed of 16.65 m.p.h., (2) round trip of 2 miles, (3) waiting time of 5 minutes at mill and 1 minute in the field, (4) 8 tons of cane per load, (5) loader capacity of 55 tons per hour.

^{2/}Based on the same assumptions as in footnote ^{1/}, except number (5). Loader (harvester) capacity is 20 tons/hour.

Conventional Louisiana System. Costs developed for a Thomson harvester and a Cameco self-propelled loader are shown in Tables 2 and 3. Total cost for the Thomson harvester was \$.941 per ton harvested. The total cost per ton loaded by the Cameco self-propelled loader was \$.203. The total harvesting and loading cost for the conventional Louisiana system was \$1.144 per ton.

Table 2. Investment cost, annual fixed cost, and hourly fixed and variable costs of a conventional Louisiana Thomson harvester.

Initial investment cost:		\$ 41,842.50
Annual fixed costs:		
Depreciation (5 year life)	\$ 8,368.50	
Interest on investment	1,673.70	
Insurance ^{1/}	287.66	
Shelter ^{2/}	418.42	
Total annual fixed cost		\$ 10,748.28
Hourly costs		
Total fixed cost/hour ^{3/}		\$ 15.355
Variable costs/hour		
Fuel (5.79 gal @ 35¢/gal)	\$ 2.026	
Engine oil (15% of fuel cost)	.304	
Repairs and maintenance ^{4/}	5.230	
Labor (operator) ^{5/}	2.500	
Total variable cost/hour		10.060
Total cost/hour		25.415
Total cost/ton (27 tons/hour)		.941

^{1/}Includes liability and physical damage coverage.

^{2/}One percent of initial investment cost.

^{3/}Based on 700 hours use per year. (70 days, 10 hours per day)

^{4/}Estimated at 1.25% of initial investment cost per 100 hours use. Costs include daily servicing, lubrication, all materials and labor, and minor and major repairs.

^{5/}USDA minimum wage rate for harvester operator during 1974 harvest.

Table 3. Investment cost, annual fixed cost, and hourly fixed and variable costs of a Cameco self-propelled loader unit.

Initial investment cost		\$ 24,150.00
Annual fixed costs		
Depreciation (10 year life)	\$ 2,415.00	
Interest on investment	966.00	
Insurance ^{1/}	154.00	
Shelter ^{2/}	<u>241.50</u>	
Total annual fixed cost		\$ 3,776.50
Hourly costs		
Total fixed cost/hour ^{3/}		\$ 4.721
Variable costs/hour		
Fuel (4.66 gph @ 35¢/gal)	\$ 1.631	
Engine oil (15% of fuel costs)	.245	
Repairs and maintenance ^{4/}	2.053	
Labor (operator) ^{5/}	<u>2.500</u>	
Total variable cost/hour		6.429
Total cost/hour		11.150
Total cost/ton (55 tons/hour)		.203

^{1/}Includes liability and physical damage coverage.

^{2/}One percent of initial investment cost.

^{3/}Based on 800 hours use per year (80 days, 10 hours per day). Loader is estimated to be used 100 hours annually for planting.

^{4/}Estimated at .85% of initial investment cost per 100 hours use. Costs include daily servicing, lubrication, tires, materials and labor, and minor and major repairs.

^{5/}USDA minimum wage rate for loader operator during 1974 crop.

Massey Ferguson 102 System. This system eliminates the use of a separate loading unit. The harvester cuts the cane, chops it into 12 - 16 - inch pieces and drops it into a wagon. The total cost per hour for this machine was \$43.658 (Table 4). The cost per ton at a capacity of 20 tons per hour was \$2.183.

The Massey Ferguson seldom cut more than 200 tons per day. A major problem holding down capacity was coordination of hauling units. Taking this into account, it appears that an efficient operation could harvest 200 tons per 10-hour day. Improvements in the harvester's capacity to cut unburned cane and to operate in muddy conditions are necessary to significantly improve its capacity.

Table 4. Investment cost, annual fixed cost, and hourly fixed and variable costs of a Massey Ferguson 102 chopper-harvester.

Initial investment cost		\$ 78,750.00
Annual fixed costs		
Depreciation (5 year life)	\$ 15,750.00	
Interest on investment	3,150.00	
Insurance ^{1/}	541.41	
Shelter ^{2/}	<u>590.62</u>	
Total annual fixed cost		\$ 20,032.03
Hourly costs		
Total fixed cost/hour ^{3/}		\$ 28.617
Variable costs/hour		
Fuel (6.70 gal @ 35¢/gal)	\$ 2.345	
Engine oil (15% of fuel cost)	.352	
Repairs and maintenance ^{4/}	9.844	
Labor (operator) ^{5/}	<u>2.500</u>	
Total variable cost/hour		15.041
Total cost/hour		43.658
Total cost/ton (20 tons per hour)		<u>2.183</u>

^{1/}Includes liability and physical damage coverage.

^{2/}One percent of initial investment cost.

^{3/}Based on 700 hours use per year (70 days, 10 hours per day).

^{4/}Estimated at 1.25% of initial investment cost per 100 hours use. Costs include daily servicing, lubrication, all materials and labor, and minor and major repairs.

^{5/}USDA minimum wage rate for harvester operator during 1974 harvest.

HAULING COSTS

Hauling costs for a John Deere Model 4230 diesel tractor and a Bob Boudreaux twin axle cart were determined. This type of cart was converted for use with the Massey Ferguson 102. Chain-link fencing was attached to the ends of the cart and inside the chain net. This conversion was relatively simple, inexpensive, and it lasted well.

Conventional Louisiana System. A hauling unit consists of a John Deere 4230 tractor and one Bob Boudreaux wagon. The total cost per hour of a hauling unit is \$10.470 (See Tables 5 and 6). The following assumptions are made in determining the cost per ton for hauling cane: 1) loader capacity of 55 tons per hour, 2) average road speed of 16.65 miles per hour for the hauling unit 3) a round trip distance to the mill of two miles, 4) a total waiting time of 5 minutes at the mill and one minute in the field, and 5) 8 tons of cane per load.

Table 5. Investment cost, annual fixed cost, and hourly fixed and variable cost of a John Deere Model 4230 diesel tractor.

Initial investment cost		\$ 16,800.00
Annual fixed cost		
Depreciation (12 year life)	\$ 1,400.00	
Interest on investment	672.00	
Insurance ^{1/}	115.50	
Shelter ^{2/}	<u>168.00</u>	
Total annual fixed cost		\$ 2,355.50
Hourly costs		
Total fixed cost/hour ^{3/}		\$ 2.356
Variable costs/hour		
Fuel (4.66 gph @ 35¢/gal.)	\$ 1.631	
Engine oil (15% of fuel cost)	.245	
Repairs and maintenance ^{4/}	2.100	
Labor (tractor driver) ^{5/}	<u>2.500</u>	
Total variable cost/hour		\$ 6.476
Total cost/hour		8.832

^{1/}Includes liability and physical damage coverage.

^{2/}1% of initial investment cost.

^{3/}Based on 1,000 hours use per year.

^{4/}Estimated at 1.25% of initial investment cost per 100 hours use. Costs include all materials and labor, daily servicing, lubrication, and minor and major repairs.

^{5/}USDA minimum wage rate for tractor drivers during 1974-crop harvest.

Table 6. Investment cost, annual fixed cost, and hourly fixed and variable costs of a Bob Boudreaux chain-net wagon.

Initial investment cost		\$ 5,544.00
Annual fixed costs		
Depreciation (12 year life)	\$ 462.00	
Interest on investment	221.76	
Insurance ^{1/}	<u>9.15</u>	
Total annual fixed cost		\$ 692.91
Hourly costs		
Total fixed cost/hour ^{2/}		\$.990
Variable costs/hour		
Repairs and maintenance ^{3/}	\$.277	
Tires ^{4/}	<u>.371</u>	
Total variable cost/hour		.648
Total cost/hour		\$ 1.638

^{1/}Physical damage coverage for 90 days. No liability coverage because carts towed by farm tractors are covered by the tractor insurance.

^{2/}Based on 700 hours of use per year.

^{3/}Estimated at 0.5% of initial investment cost per 100 hours use. Includes all repairs and maintenance.

^{4/}Estimated replacement every 2,100 hours of use at \$780 per set of four tires.

Using these assumptions, the complete cycle of loading, hauling, unloading, and returning to the field should take 21.93 minutes. A hauling unit would haul 21.89 tons per hour. The cost per ton for hauling cane would be \$.478 per ton.

Massey Ferguson 102 System. The hourly cost of a hauling unit with the converted Bob Boudreaux wagon is \$10,560 (See Tables 5 and 7). The only assumption different from those used for the conventional system concerns loader capacity. The loading capacity of the Massey Ferguson 102 is assumed to be 20 tons per hour.

Table 7. Investment cost, annual fixed cost, and hourly fixed and variable costs of a converted Bob Boudreaux chain-net wagon.

Initial investment cost		\$ 5,942.00
Annual fixed costs		
Depreciation (12 year life)	\$ 495.17	
Interest ^{1/} on investment	237.68	
Insurance ^{1/}	<u>8.92</u>	
Total annual fixed cost		\$ 741.77
Hourly costs		
Total fixed cost/hour ^{2/}		\$ 1.060
Variable costs/hour		
Repairs and maintenance ^{3/}	.297	
Tires ^{4/}	<u>.371</u>	
Total variable cost/hour		.668
Total cost/hour		\$ 1.728

^{1/}Physical damage coverage for 90 days. No liability coverage because carts towed by farm tractors are covered by the tractor insurance.

^{2/}Based on 700 hours of use per year.

^{3/}Estimated at 0.5% of initial investment cost per 100 hours use. Includes all repairs and maintenance.

^{4/}Estimated replacement every 2,100 hours of use at \$780 per set of four tires.

Using these assumptions, a complete cycle of loading, hauling, unloading, and returning to the field should take 37.21 minutes. A hauling unit would haul 12.90 tons per hour. The hauling cost would be \$.819 per ton.

COSTS AND RETURNS

Appendix Table III shows that the average calculated gross tons per acre, standing in the field for the three tests were almost equal for the two systems. Using the average data for the three tests and the cost data for each system, harvesting and hauling costs, and the returns for an "Average" acre of cane were determined (See Table 8).

Table 8. Costs and returns for the Massey Ferguson 102 and the conventional Louisiana harvest systems.^{1/}

Item	Conventional system	M.F. 102
	- - - - - (Dollars/acre) - - - - -	
Costs		
Harvest	28.36	75.01
Load	6.12	-
Haul	<u>14.41</u>	<u>28.14</u>
Total cost	48.89	103.15
Returns ^{2/}	1,491.50	1,427.00
Return above selected costs	1,442.61	1,323.85

^{1/}Based on yield, trash, sucrose and purity data in Tables 2 and 3.

^{2/}Based on price of \$50.00 per standard ton.

Conventional Louisiana System. An average of 30.14 gross tons of cane per acre were hauled to the mill. It cost \$.941 per ton to harvest, \$.203 per ton to load, and \$.478 per ton to haul the cane, for a total cost of \$1.622 per ton. The total cost per acre was \$48.89 (\$1.622 x 30.14 gross tons per acre).

These 30.14 gross tons converted to 29.83 standard tons.

Assuming a price of \$50.00 per standard ton of cane, the average return per acre was \$1,491.50 (\$50.00 x 29.83 standard tons per acre). The average return above harvesting and hauling costs for the conventional system was \$1,442.61.

Massey Ferguson 102 System. An average of 34.36 gross tons of cane per acre were hauled to the mill. It cost \$2.183 per ton to harvest and load, and \$.819 per ton to haul the cane to the mill. The total cost was \$3.002 per ton. The cost per acre was \$103.15 (\$3.002 x 34.36 gross tons per acre).

These 34.36 gross tons converted to 28.54 standard tons.

With a price of \$50.00 per standard ton of cane, the average return per acre was \$1,427.00 (\$50 x 28.54 standard tons per acre). The average return above harvesting and hauling costs for the Massey Ferguson 102 system was only \$1,323.85 per acre.

CONCLUSIONS

This was the first year that the Massey Ferguson 102 operated in Louisiana. A great deal of experimenting was necessary to make the machine perform properly under Louisiana conditions. Changes and adjustments were made on the harvester on a day-to-day basis. Row heights were much higher than those normally encountered by the machine. A lack of hauling units often limited its capacity.

Taking all of these factors into account, the Massey Ferguson 102 should be able to harvest about 20 tons of cane per hour. If further improvements are made in the machine's capacity to cut unburned cane and its ability to operate in muddy conditions, its capacity could be increased significantly.

The problem of lower sucrose with the Massey Ferguson-cut cane appears to be caused by poor topping. The sucrose difference between the two systems was much less in Test 3 than in the other tests. The cane in Test 3 was more erect and the Massey Ferguson appeared to be topping the cane much lower. A new topping system may be installed on the machine for next harvest season.

Although the data in this study show that it is much more expensive to harvest cane with the Massey Ferguson 102 than with the conventional Louisiana system, we should not give up completely on the Massey Ferguson 102 or on other chopper harvesters. Since this was the first year the harvester has operated in Louisiana, improvements in the machine may make it more competitive in the future.

Many Louisianians have been and continue to be interested in experimenting with chopper harvesters because they offer several potential advantages. These are: 1) fresher cane delivered to the mill, 2) less field mud in trash, and 3) less ground loss.

Complete reliance on the type of chopper harvesters now in commercial use would probably be a mistake in Louisiana. The danger exists that there may be years when an early freeze occurs and cane is down in such a way that the chopper harvester cannot top frozen joints effectively. Under these conditions, cane processing might come to an abrupt halt if we were completely dependent on harvesters which do not have the ability to selectively top cane.

In spite of this, more Louisiana testing of the Massey Ferguson 102 and other chopper harvesters should be encouraged. They may have a use on a supplementary basis in Louisiana.

Appendix Table I. General information - Tests comparing Massey Ferguson 102 and conventional Louisiana harvester.

Test No.	Type of harvester	Date of test	Location of test	Acres harvested	Variety harvested
1	M.F. 102	11/13/74	Georgia	4.8	CP 61-37
	Conventional	11/13/74	Georgia	4.4	CP 61-37
2	M.F. 102	12/4/74	Georgia	4.3	CP 61-37
	Conventional	12/6/74	Georgia	5.3	CP 61-37
3	M.F. 102	12/17/74	Oaklawn	2.6	CP 52-68
	Conventional	12/19/74	Oaklawn	2.3	CP 52-68

Appendix Table II. A comparison of trash, sucrose, and purity - Massey Ferguson 102 vs. conventional Louisiana harvester.

Test No.	Type of harvester	Percent trash	Normal juice sucrose	Normal juice purity
1	M.F. 102	11.58	10.23	68.70
	Conventional	13.39	12.15	74.00
2	M.F. 102	7.72	11.55	76.69
	Conventional	9.00	13.20	79.66
3	M.F. 102	7.60	13.05	75.61
	Conventional	3.58	13.26	74.37
Average	M.F. 102	8.97	11.61	73.66
	Conventional	8.66	12.87	76.01

Appendix Table III. A comparison of cane yields - Massey Ferguson 102 vs. conventional Louisiana harvester.

Test No.	Type of harvester	Calculated ^{1/} gross tons/acre, standing in field	Gross tons ^{2/} harvested/acre	Gross tons ^{3/} scrap/acre	Standard tons ^{4/} harvested/acre	Harvesting ^{5/} efficiency index
1	M.F. 102	38.19	34.03	4.16	21.73	95.21
	Conventional	37.18	25.82	11.36	22.22	100.00
2	M.F. 102	49.77	45.02	4.75	39.90	93.37
	Conventional	43.28	36.10	7.18	37.16	100.00
3	M.F. 102	26.19	24.04	2.15	23.97	97.48
	Conventional	32.06	28.48	3.58	30.10	100.00
Average	M.F. 102	38.05	34.36	3.69	28.54	95.35
	Conventional	37.51	30.14	7.37	29.83	100.00

^{1/}Column 4 plus Column 5.

^{2/}This was amount hauled to the mill and does not include any cane scrapped behind the harvester or loader.

^{3/}This was amount of cane left in the field, measured for experimental purposes.

^{4/}This is the gross tons in Column 4 adjusted by the data on trash, sucrose, and purity appearing in Table 2.

^{5/}Divide Column 6 by Column 3. For each test, convert these figures to index numbers, allowing conventional harvester to equal 100. Example for Test 1:

$$\begin{aligned} \text{Conventional: } & 22.22 \div 37.18 = .5976 \\ & (.5976 \div .5976) \times 100 = 100 \end{aligned}$$

$$\begin{aligned} \text{M.F. 102: } & 21.73 \div 38.19 = .5690 \\ & (.5690 \div .5976) \times 100 = 95.21 \end{aligned}$$

TOLERANCE OF SUGARCANE TO HERBICIDES^{1/}

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ABSTRACT

When not controlled common weeds of sugarcane--johnsongrass (Sorghum halepense (L.) Pers.), itchgrass (Rottboellia exaltata L.f.), browntop panicum (Panicum fasciculatum Swartz.), morningglory (Ipomoea spp.), winter annual weeds, and summer grasses--will reduce yield of sugarcane 10-50% or more. In comparison, yield losses that may occur from herbicide injury usually are less than 10%. Crop safety is one of the primary research objectives when developing herbicide programs. Herbicides commonly used in sugarcane may be broadly classified as soil applied or foliage applied. The herbicides 3-tert-butyl-5-chloro-6-methyluracil (terbacil), (2,3,6-trichlorophenyl)acetic acid (fenac), a,a,a,-trifluro-2,6-dinitro-N,N-dipropyl-p-toluidine (trifluralin), sodium salt of trichloroacetic acid (TCA), (2,4-dichlorophenoxy)acetic acid (2,4-D), 2-(2,4,5-trichlorophenoxy)propionic acid (silvex), 2-chloro-4,6-bis(ethylamino)-s-triazine (simazine), and 3-(3,4-dichlorophenyl)-1,1-dimethylurea (diuron) are commonly applied to soil for preemergence control of weeds in sugarcane. The herbicides 2,2-dichloropropionic acid (dalapon), methyl sulfanilylcarbamate (asulam)--an experimental herbicide not registered by the Environmental Protection Agency for use in sugarcane as of July, 1975--2,4-D, silvex, and 2-(ethylamino)-4-(isopropylamino)-6-(methylthio)-s-triazine (ametryne) are commonly applied to foliage of weeds for contact or translocation kill of weeds. Research has shown that all of these herbicides can be used safely but certain precautions are needed to prevent injury to sugarcane from the more phytotoxic ones. Fenac can injure sugarcane roots and reduce yield, particularly on heavy clay soils or on very porous soils. The sugarcane cultivar CP 48-103 is sensitive to terbacil and cultivars CP 44-101 and CP 52-68 are sensitive to diuron. Dalapon can be phytotoxic to all cultivars but CP 48-103, L 60-25, L 62-96, and NCo 310 are more sensitive than others. Dalapon is most injurious to sugarcane when more than one application is made during a season or when application is made in late spring or summer. Asulam, a new herbicide with weed control properties similar to dalapon, is much less phytotoxic to sugarcane. Herbicides that have proven to be exceptionally nonphytotoxic to sugarcane are simazine, trifluralin, TCA, the amine salt of 2,4-D, and silvex.

^{1/}Research at this laboratory is in cooperation with the Louisiana Agricultural Experiment Station.

STUDIES OF RODENT DAMAGE AND RODENT POPULATION DYNAMICS
IN FLORIDA SUGARCANE

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The U.S. Fish and Wildlife Service, as part of its responsibility for resolving or ameliorating conflicts between man and animals, has studied animal depredations on agricultural crops for many years. Among these crops has been sugarcane (*Saccharum* hybrids) in Hawaii (Hood 1968, Hood *et al.* 1970, Nass *et al.* 1971), where rat control methods have been developed and research to reduce damage continues. Rat (*Sigmodon hispidus*, *Rattus rattus*, and *Neofiber alleni*) depredations on Florida sugarcane have been documented by several researchers (Doty 1960, Madsen 1964, Samol 1972). In 1974, Service biologists began studying this problem in Florida. The first stage of our research entails collection of certain basic data on rats and their damage to sugarcane in this region. Information obtained from analysis of these data will enable us to design and evaluate field tests of control methods, which could include chemical, behavioral, and mechanical techniques.

Date collection to date have dealt with damage assessment, rodent abundance and distribution, and rodent reproductive biology. Most of the studies are still underway, and the data have yet to be analyzed.

RODENT DAMAGE ASSESSMENT

Since April 1974, a monthly assessment of rodent damage to sugarcane has been conducted in two study areas to determine the timing of damage in relation to the sugarcane growth cycle, and the damage distribution within Florida sugarcane fields.

The study areas are one half of two fields: the south half of 45-P-13, located in the Miami Locks plantation of the U.S. Sugar Corporation; and the north half of 2ES, located in the mill lot of the Okeelanta Division of the Gulf and Western Food Products Company. Six transects were established in each study area shortly after the 1974 harvest. The transects were stratified to sample equally three areas of each half-field: the edge, middle, and middle ditch (Fig. 1).

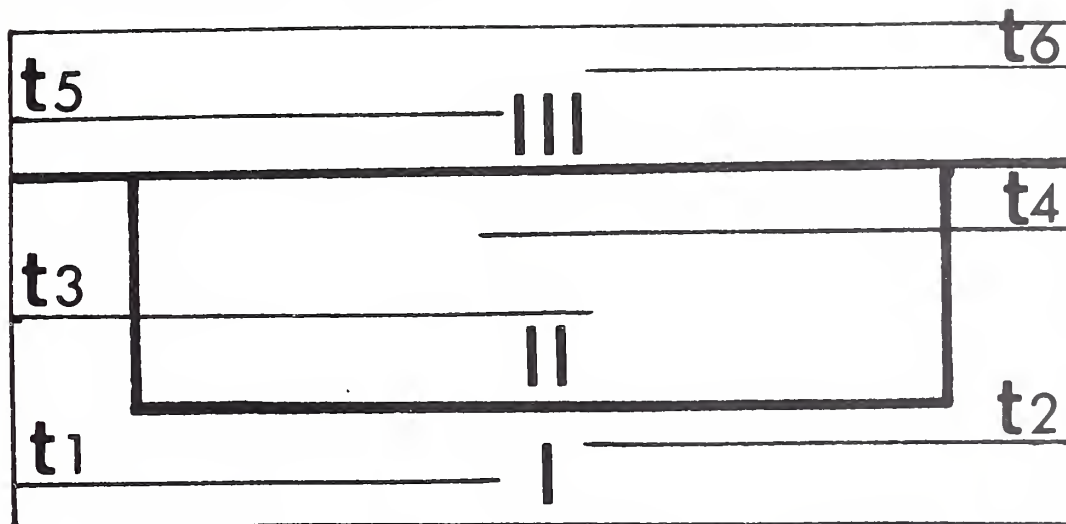


Fig. 1. Layout of study area showing the transects, t_1 - t_6 , and the strat, I-III.

In Hawaii, damage was heaviest on the edges of fields, moving inward as the growing cycle progressed.

Sampling units, each consisting of 8 feet of cane row, were established at 50-foot intervals along the transects. The sampling units are examined every month for damage. Each damaged stalk

within the sampling units is tagged, and its damage recorded. Formerly-tagged stalks are re-examined for new damage, and to determine condition of the stalk. Four degrees of damage are recognized:

1. stalk gnawed, but not into
2. stalk gnawed into pulp, but less than halfway through
3. stalk gnawed more than halfway, but not all the way through
4. stalk gnawed through

Damaged sprouts also are tagged and recorded, although we are uncertain to what degree rabbits (*Sylvilagus palustris* and *Sylvilagus floridanus*) rather than rats might be responsible for sprout damage. In general, we have found that damage becomes appreciable in August and increases throughout the fall.

During the 1975 harvest, Service personnel conducted a damage assessment study, which was supported by the Florida Sugar Cane League. Damage was assessed in 40 fields of the U.S. Sugar Corporation shortly after the cane had been cut. The pile rows were stratified (Fig. 2) in the same manner as the transects in the two study areas previously described. One sample point was randomly selected per pile row in Strata II, III, and the long portion of I on each half of a field. Three additional sample points were selected for the short portions of Stratum I on each half-field.

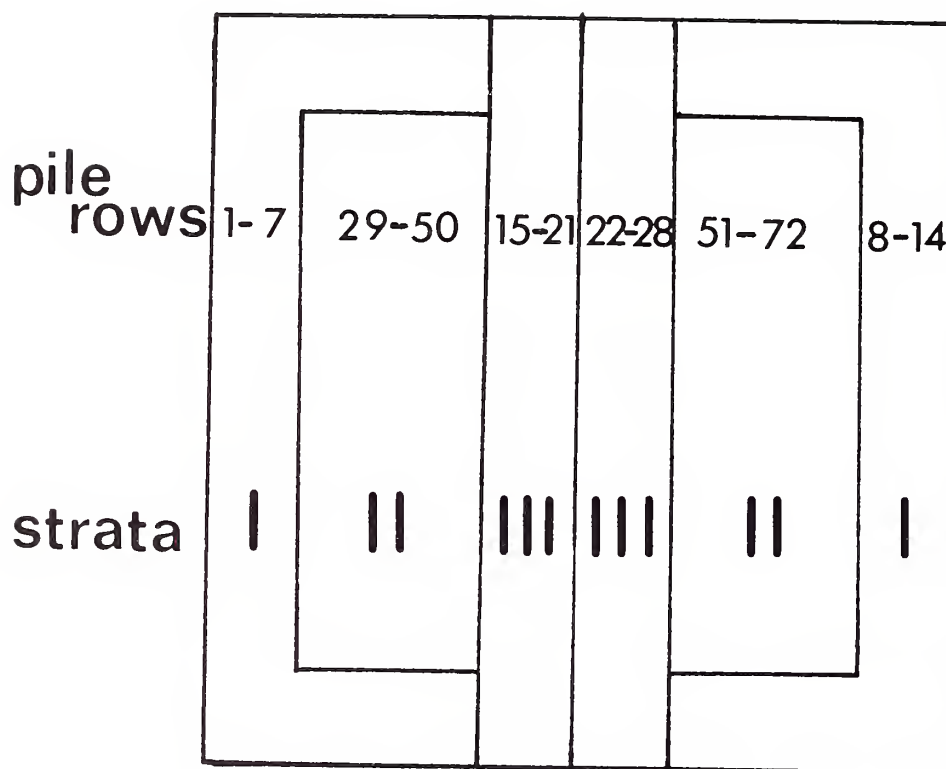


Fig. 2. Field layout for harvest damage assessment.

From each sample point, 25 stalks were randomly selected and examined for damage. The number of internodes damaged and the degree of damage at each internode were recorded by sample-point location. These data are being analyzed to determine the variation in rodent damage between fields and within fields. Such information is important in determining the number of fields necessary for field-testing candidate rodenticides, and in designing a sound field test. We will also test for possible correlation of percentage damaged stalks with production figures from these fields: tons per acre, sugar yield, brix, and pol. Cane variety, age, and location will also be examined.

RODENT POPULATION DYNAMICS

In April 1974, we began a monthly live-trapping study to determine rat abundance, movements, and distribution in sugarcane fields. Knowledge of variation in population size of depredating rodents, especially when periods of population peaks and lows occur, is important in determining timing of control methods. Knowing when and where the rats are most abundant in the cane, what their movement patterns are, and how these variables relate to rat damage is essential in understanding the significance of rat depredation to Florida's sugarcane crop, and in developing means of reducing rat damage. The live-trapping study is conducted in the same study areas as the damage assessment study. The 76 sampling units established in each study area for damage assessment are also used as trap sites. Rats are trapped for 8 successive days each month. Each rat is weighed and numerically marked for future identification by toe-clipping and ear-tagging.

In 18 months of live-trapping, we have marked 312 cotton rats (*Sigmodon hispidus*), 153 black rats (*Rattus rattus*), 15 Florida water rats (*Neofiber alleni*), and 2 rice rats (*Oryzomys palustris*) in 45-P-13; in 2ES we have marked 861 cotton rats, 5 black rats, 4 Florida water rats, and 9 rice rats.

Our trapping scheme will not provide an index of water rats, because this species must be trapped at its burrows to capture a representative sample. We have also encountered difficulty re-trapping black rats after their initial capture and marking. Cotton rats, however, are readily trapped and re-trapped.

Monthly live-trapping along the perimeters of the study areas was begun in March 1975 to obtain information on rat movements into and out of fields. By perimeter, we mean the edges of fields directly adjacent to the study areas, which in some instances are separated from the study areas by one or two canals. For both study areas, the edge of the other half of the field, bordering the middle ditch, forms a portion of the perimeter.

Knowledge of the seasonal pattern of reproduction and the reproductive potential of a species is required to understand that species' population dynamics, and its ability to recover from a population reduction. We have been taking monthly reproductive samples from cotton rats, black rats, and Florida water rats since May 1974. These rats appear to be the predominant rodent species in the areas we are trapping: the Western Division of the U.S. Sugar Corporation and the mill lot of Okeelanta Division, excluding our live-trapping study areas. We attempt to obtain a minimum monthly sample of 20 of each species, 10 of each sex. The reproductive tracts are preserved for future histological study.

Further study of the reproductive tissues will yield information on seasonal testicular cycles, monthly prevalence of pregnancy, and monthly and yearly productivity of these rodent species.

SUMMARY AND FUTURE PLANS

Our research efforts thus far have emphasized rodent damage patterns in sugarcane and population dynamics of rodents detrimental to sugarcane. Data collection for this phase of research will be completed in April 1976. Development and evaluation of control methods will be based on the findings of our current studies.

As Harry Samol (1971) indicated, the Florida water rat may well require different control measures than do cotton rats and black rats because of its primarily subterranean existence. A 2-year study on the distribution of the water rat in sugarcane, and the extent of its damage within a field, will be conducted by a graduate student supported by the Florida Sugar Cane League and the U.S. Fish and Wildlife Service.

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